APR 20 1933

INSTRUMENTS

THE MAGAZINE OF MEASUREMENT AND CONTROL

VOLUME 6 APRIL, 1933 NUMBER 4

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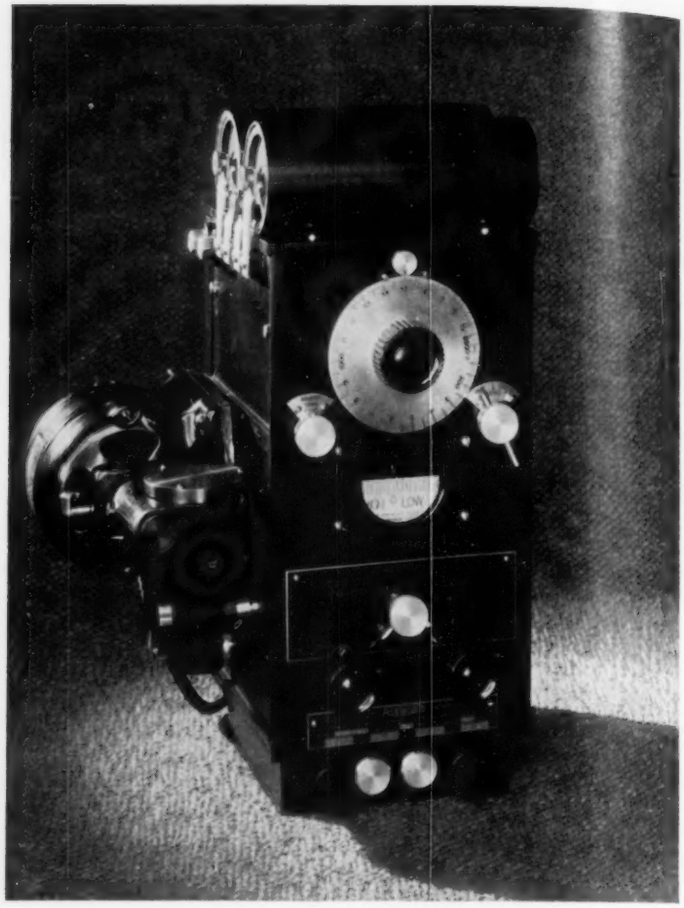
TEMPERATURE and HUMIDITY MEASUREMENT and CONTROL



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EDITORIAL COMMENT

In This Issue

♦ In general, the engineer's task is to "conquer the forces of Nature." As is pointed out in "Fundamentals of Instrumentation," however, the solution lies in *isolating* variables and *measuring* them in order to *control* them. **Crankshaft Whip and Vibration** are elusive things of just this kind—until they become measurable. Then knowledge replaces guesswork, as **M. M. Roensch** relates on pages 75-76.

♦ **F. L. Spangler** tells, in this month's instalment of **Control of Fractional-Horsepower Motors,** of no-voltage protection and special service requirements. In spite of the word "special" this article is of general interest.

♦ **Prof. DeJuhasz** takes up this month the various high-pressure types of **The Engine Indicator** and tells of several most ingenious devices including—by pure coincidence—a stroboscopic device of the same general type as that described by M. M. Roensch elsewhere in this issue.

♦ Gas measurement in industry is an important branch of engineering and the editor expects that **M. F. Béhar's** discussion of **Positive Gas Meters,** beginning in this issue, will prove useful to many readers.

♦ Among the regular features, readers will note that we print this month an unusually large number of **Book Reviews.** Thirty articles make up the **New Instruments** Department and describe not only re-designed instruments but several radically new ones; while the **Manufacturers' Literature** (pages 78-79) lists many new publications, including some you should send for.

◆ ◆ ◆

The Front Cover

♦ Visitors to Atlantic City may remember the Glen Logan Bakery and its delicious macaroons. These are baked in the good-looking battery of ovens shown on our cover with their Bristol electric-contact type temperature controllers.

Training in Measurement and Control for Engineers

THERE is a large and growing need for training engineers in the theory and practice of measurements for industrial control. Efforts to reduce costs and improve the quality of production have resulted in the widespread use of accurate measurements of temperature, pressure, humidity, viscosity, physical dimensions, fluid flow and the like. Operations which formerly depended entirely upon the judgment of an experienced operator have been vastly improved by the use of instruments approaching laboratory standards of accuracy for indicating, recording, and even controlling important properties and the conditions which affect them. As a result of this growth almost every industrial plant of any size has need for the services of an engineer who understands modern instruments, if only to look after the maintenance of those which have already been installed. In a paradoxical way the extensive installation of measuring equipment has in no way diminished the possibilities for the introduction of more such devices but has increased the general knowledge and appreciation of the benefits to be derived so that there are actually more possibilities today than there were ten years ago. Let no one think that the plant instrument engineer's horizon will be limited to the problems involved in the maintenance of equipment already installed.

The builders of instruments and their sales engineers deserve the highest praise for the part they have played in the introduction of rugged instruments suitable for industrial use. Starting with the flimsy and cranky pyrometers of fifteen years ago, for example, they have evolved accurate and reliable machines capable of measuring the feeble electro-motive forces developed by thermocouples with a precision better than one half of one percent. They have sought out profitable applications for these machines and they have educated industry in their use. That which has been done is remarkable, but that which will be done in the next few years will seem more remarkable. We visualize the development of pyrometer controllers which will be bought, sold, and applied with as much freedom as electric motors are now handled. This will be possible largely because of improvements in the design, but partly because of a more common understanding of their use by engineers. These improvements will bring about a reduction in the cost of such controls which will still further encourage their use. Instruments for measuring other conditions and properties will be developed in a similar way.

The time has come when the great engineering schools ought to recognize the growing importance of these matters in industry by the establishment of special departments of Industrial Measurement and Control which would be charged with the duty of training every engineer in the theory and use of those instruments which directly affect his branch of engineering, with the training of a few specialists who will help with the development and production of instruments for all, and with the conduct of research in the design and application of instruments. Such a department would render an invaluable aid to industry, first by providing engineers who would locate the useful and profitable applications for measuring and controlling machines, second by training instrument specialists who would coöperate in the development of those devices best suited to these applications, and last by the results of its own research in the field of industrial measurement and control.

The above was written after a discussion with an engineer, who is in responsible charge of the measurement and control work of one of the largest and most progressive users of industrial instruments in America. We are more than pleased to feature his ideas and to offer to any college or university, which may consider the establishment of such a department the wholehearted coöperation of INSTRUMENTS.

—Richard Rimbach.

INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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RICHARD RIMBACH, Managing Editor

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Control of Fractional-Horsepower Motors

By F. L. SPANGLER*

(Continued from March issue)

Magnetic Control—No-voltage Protection

Many types of machines used in different industries would constitute a hazard to human life and perhaps valuable work in process would be spoiled should these machines start up unexpectedly after being stopped by a temporary loss of power. Protection against such a contingency is known as no-voltage protection, and requires the use of magnetically operated switches. With the hand operated across-the-line starters already considered, should the voltage fail while the motor is operating, the switch will not open although the motor will come to a standstill; then upon return of voltage the motor will restart, unless meanwhile the control circuit has been opened by hand. Therefore, these starters do not provide no-voltage protection. The same is generally true of motors operated by float switches, pressure switches, and other two-wire control devices.

A typical wiring diagram for a 3-phase across-the-line automatic switch giving overload and also no-voltage protection is shown in Fig. 5. This switch is controlled through a pilot push-button station consisting of "Start" and "Stop" buttons. The contacts of the "Start" button are closed and those of the "Stop" button are open only so long as either button is held down by the finger. Upon being released by removing the finger, the button returns to its normal position. When the switch is closed, the contacts of the "Start" button are shunted through a fourth pole mounted on the switch armature. This fourth pole, known as the hold-in contact, provides a by-pass around the "Start" button to the hold-in coil of the switch, so the switch remains closed even after the "Start" button has been released. The hold-in contact often is not a fourth pole, but is obtained through some other type of auxiliary arm on the switch armature which makes contact when the switch closes.

The current to the hold-in coil of the switch always passes through the "Stop" button and the control contacts of the overload relays. Hence, pressing the "Stop" button, or tripping either overload relay, breaks this circuit, and the switch opens. With the switch open, the hold-in contact is broken, and to reclose the switch it is necessary again to press the "Start" button. Should the switch open as a result of temporary loss of line voltage or for some other cause, it still is necessary to press the "Start" button to reclose the switch, thereby giving complete safety protection against accidental restarting after shutdowns for any cause.

Because the "Start" button used in this type of control makes contact only while it is held in by the finger and breaks contact at the moment it is released, it is known as a momentary-contact type of button. Likewise the contacts of the "Stop" button, which are of the normally closed type, are open only while the finger is pressing on the button, and the contacts close at the moment the button is released. In this kind of pilot control, 3 wires are required between the magnetic switch and the push-button station. One of these wires connects with one of the incoming power leads; another connects with a second incoming power lead through the hold-in coil and the overload relay contacts; while the third is connected to the hold-in contact on the switch armature.

*Industrial Engineer, Allen-Bradley Co.

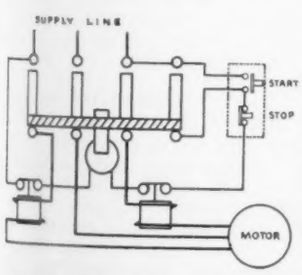


Fig. 5. Wiring diagram of a magnetic switch with overload relays and controlled through a "Start"-"Stop" push-button station for control of a three-phase a.c. motor.

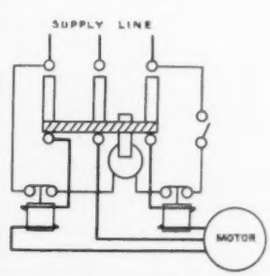


Fig. 6. Diagram of connections where the motor starting switch is controlled through a pressure switch or other two-wire control device.

Where the switch is used to control motors driving air compressors, refrigeration machinery, pumps, oil burners, and in other applications in which the starting and stopping of the motor are made dependent on liquid level, pressure, temperature or other condition, the control of the magnetic switch will usually depend on some automatic contact-making device such as a pressure switch, float switch, or thermostat. In this case, the control circuit shown in Fig. 6 would be used. Here there are only 2 control wires between the pilot device and the magnetic switch, and the hold-in contact is eliminated. This

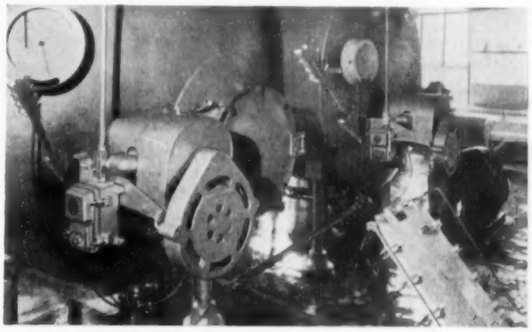


Fig. 7. In dairies, bottling plants, etc., motor starters must often be protected against the entrance of spray and moist air. The two starters shown are provided with rubber gaskets between the enclosing boxes and covers for moisture-proofing.

control, known as 2-wire control, does not give no-voltage protection, since a return of line voltage following a temporary loss of power causes the switch to reclose and starts the motor. However, such installations do not require no-voltage protection in view of the fact that the control of the motor is at all times independent of the action of the operator, as long as the pilot control is functioning. Hence, starting of the motor by a return of power to the supply line creates no greater hazard than when the motor is started by a low liquid level or a low steam pressure.

With 2-wire control, should the voltage fail while the switch is closed and the motor is operating, the hold-in coil of the switch will necessarily become de-energized and the switch will open and disconnect the motor from the line. The switch will reclose when the line voltage again is built up to near its normal value. With 3-wire control the switch will not reclose even if line voltage is restored until someone willfully presses the "Start" button.

Special Service Requirements

Magnetic starting switches installed out-of-doors or in moisture-laden atmospheres of tanneries, laundries, dairy plants, pumping stations, etc., must exclude water spray and moisture. The water-tight starting switches shown in Fig. 7 are enclosed in boxes provided with tight-fitting covers. A rubber gasket between the box and cover makes an effective seal, and the splash-proof construction of the push buttons prevents the entrance of moisture. The cover is drawn down tight with hinged bolts and wing nuts.

In explosive atmospheres of inflammable gases, vapors, or dust, open switches present a hazard to life and property, since arcing at the contacts may ignite the gas or dust and cause an explosion. For such hazardous locations, the National Electric Code sets up special regulations regarding the design of motors and control equipment and installation of wiring. Fig. 8 shows the interior of a switch that meets the requirements of the Underwriters Laboratories for Class 1 hazardous locations described in Article 32 of the National Electric Code, which includes chemical plants, dry-cleaning plants, varnish manufacturing plants, spray painting establishments, and other places where the switch operates in an explosive atmosphere. This switch is enclosed in a heavy cast-iron box. The wide flanges of the box and cover are machined to make a tight fit, and the faces are held together by four swivel bolts with hexagonal nuts. To wire this switch, the conduit is screwed

Fig. 8. Motor starting switch for operation in explosive atmospheres must be able to withstand the force of any explosion that might occur within the switch box and prevent the escape of the flames into the room. This explosion-proof starting switch has a box and cover with flanged faces machined to make a close fit when the hexagonal holding nuts are drawn tight against the cover lugs.

into a threaded boss at the top or bottom of the box. After the wires are connected, the conduit opening is sealed with an insulating compound to prevent the passage of gases or vapors through the conduit system. With the cover in place and the nuts tightened, the flame from any explosion that might occur within the box cannot escape into the surrounding atmosphere because of the close fit between the cover and box. The castings are heavy enough to withstand the force of any such explosion; and the hot gases can escape only very slowly between the face of the cover and box, so that when they reach the outside they are sufficiently cooled and will not ignite the gas or dust in the room. The use of hexagonal nuts instead of wing nuts makes it impossible to open the switch box except with proper tools, thereby rendering unlikely any unauthorized opening of the box or tampering with the switch.

Reducing Wiring Expense

Many local codes require that some means be provided to completely disconnect the starter from the supply line. Therefore, a fused disconnect switch is installed ahead of the starter —that is, between the starter and the power supply. To save wiring and installation costs, the across-the-line starting switch and the disconnect switch may be obtained in a common cabinet, with or without fuse clips, like the switch shown in Fig. 9. All connections between the disconnect switch, fuses, and starting switch are already made, so the installer needs only to connect the motor leads and the control wires to the terminals at the bottom of the panel and the line leads to the terminals at the top. The disconnect switch, which is mounted at the top of the panel, is operated by a hand lever from outside the cabinet. The starting and disconnect switches are equipped with arc hoods or arc barriers to confine and extinguish the arcs. In the illustration, the one-piece arc hood has been removed from the disconnect switch and is lying on top of the cabinet. The starting switch is isolated completely from the line by throwing the disconnect switch to its "Off" position.

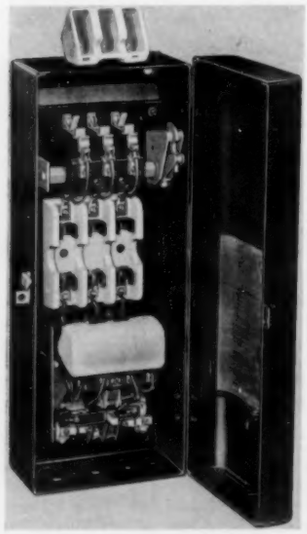


Fig. 9. By mounting the disconnect switch and the starting switch as a single unit in one cabinet, the trouble and expense of wiring are somewhat reduced. This starting switch for small motors has the disconnect switch at the top operated by an exterior handle and with the arc hood removed and laid on top of the box. Below the disconnect switch are the fuse clips and at the bottom is a magnetic starting switch provided with overload relays which can be reset outside the cabinet.

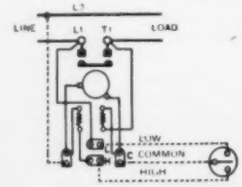


Fig. 10. Where thermostats and other pilot controls employ mechanisms of the slow-moving type, the switch hold-in coil should be opened by being short-circuited through resistors, thereby relieving the pilot contacts of breaking the coil current. This scheme of connections shows how this method is applied to a single pole switch.

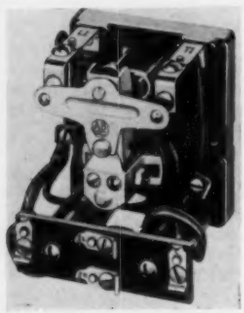


Fig. 11. Single pole switch with resistors self-contained for use with a slow moving 3-wire pilot device as shown in Fig. 10.

Where d.c. and single-phase a.c. motors are to be controlled through a 3-wire pilot device of the slow-moving type such as a thermostat, the circuits shown in Fig. 10 can be used. The purpose here is to prevent destructive arcing at the contacts of the thermostat, in view of the fact that many such pilot devices have an extremely small arc-rupturing capacity, particularly when the moving element is actuated very slowly. The moving element of the pilot device is connected to the common wire of the control circuit, and when it touches the "low" or "cold" contact, the contactor coil is energized. This closes the contactor, which remains closed until the element moves away from the "low" contact and touches the "high" or "hot" contact, thereby short-circuiting the coil through a resistor and causing the contactor to open. This control is very similar to the push-button control shown in Fig. 5, but it also includes short-circuiting resistors which relieve the pilot contacts of carrying or breaking the current to the hold-in coil of the switch. Thus destructive arcing and pitting of the contacts are prevented. A small contactor with resistors self-contained, connected as shown in the diagram, Fig. 10, is illustrated in Fig. 11. This contactor has a shading coil in the face of the magnet core to maintain a uniform pull on the armature and to eliminate the humming noise often associated with a.c. magnetic switches. The d.c. switch of the same type is not equipped with a shading coil.

For quietness in operation, the shading coil is virtually a necessity with a.c. magnetic switches. The effect of the shading coil is to cause the cycle variations in the magnetic flux passing through the shading coil to lag behind the cycle wave of the flux passing through that part of the core face lying outside the shading coil. Hence, the magnetic flux is split into two paths, each of which has similar cyclic variations and maximum and zero points; but owing to the lag produced by the shading coil, the zero points of both flux streams do not occur together and hence at every instant there is a magnetic pull on the armature.

◈ ◈ ◈

Dr. Edward Weston has been awarded the 1932 Lamme Medal of the American Institute of Electrical Engineers "for his achievements in the development of electrical apparatus, especially in connection with precision measuring instruments." At the Summer Convention of the Institute to be held in Chicago, June 26-30, Dr. Weston will be formally presented with this medal, awarded annually as a result of a bequest of B. G. Lamme, Chief Engineer of the Westinghouse Electric & Mfg. Co., who died in 1924, to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery." Previous awards of the medal were: Allen B. Field (1928), Rudolph E. Hellmund (1929), William J. Foster (1930), and Giuseppe Faccioli (1931).

Founder and now Chairman of the Board of the Weston Electrical Instrument Corp., Edward Weston was born May 9, 1850, in England, where he received his formal education. From boyhood he was devoted to experiments in chemistry and electrometallurgy. He came to New York in 1870, spent a year with a small firm of manufacturing chemists, then became chemist and electrician with the American Nickel Plating Co., and from 1872 to 1875 was in the nickel plating business on his own account. He made important improvements in the quality and speed of electroplating and developed practical and economical methods for electrolytic copper refining. The dynamo, invented some years earlier, had not come into prac-

(Continued on Page 76)

The ENGINE INDICATOR

Its Design and Theory

By KALMAN J. DeJUHASZ*

(Continued from March Issue)

INDICATORS FOR HIGH PRESSURES

For indicating pressures of several thousands of lbs./in.^{2} such as occur in pneumatic gun carriages for heavy ordnance, or in hydraulic pumps, a special form of pencil type indicator has been developed by the Crosby Company which is shown on Fig. 96. This has a piston area of 1/40 in.^{2} and is provided with a by-pass valve, in order to admit the pressure to the larger piston above, if the pressures are not too high for the capacity of the spring. This by-pass is closed whenever the small piston is to be used. The pencil mechanism is provided with a post, bearing lightly on the pencil arm in order to keep the pencil in contact with the drum. This type of indicator gives good diagrams, provided the pressure change is not too rapid.

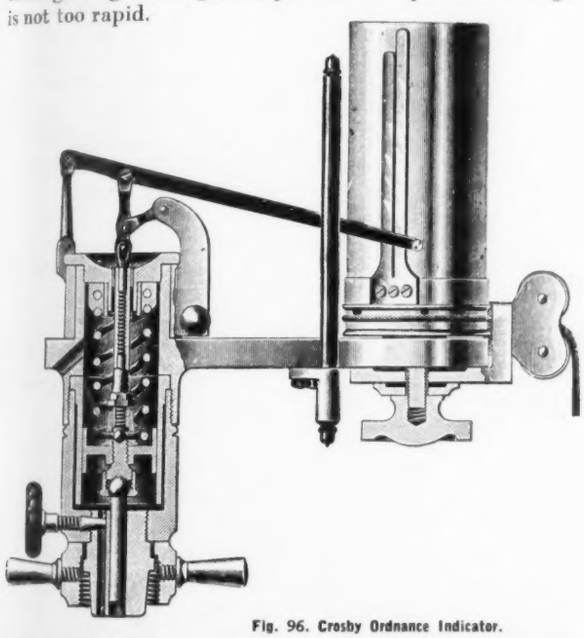


Fig. 96. Crosby Ordnance Indicator.

For rapid pressure changes coupled with high pressures, such as occur in bombs in which an explosive charge is exploded, or in guns and rifles (up to 50,000—60,000 lbs./in.^{2} in 0.003 ~ 0.004 sec., with temperatures up to 3500° C.) the natural vibration period of the indicator must be extremely small. For this purpose Prof. L. P. G. P. Thring, Cambridge, England, has designed an optical indicator which has been further developed by Dr.-Ing. Hans Rumpff.[23] The essential feature of this instrument is the indicator spring which consists of two concentric tubes, the outer one being in tension and the inner one in compression when the piston is subjected to pressure. The elastic deformation of the tubes is transferred to a mirror the deflections of which are photographically recorded. In a bar in tension or compression all the elementary filaments are equally stressed (in contra-distinction to bending and torsion). Therefore its resilience per unit weight and consequently its natural period of vibration is highest in this kind of stress. It is stated that in virtue of the inherently high natural frequency of this type of spring the natural period of vibration of the piston of this instrument can be as short as 0.00007, 0.00005 or even 0.00002 sec.

In Fig. 97a, B is the body which is screwed into a specially built breech block of a test rifle. The upper extension of B forms the "outer tube" mentioned above which at its upper end is connected to the "inner tube" C. The lower extremity of this latter is closed and forms the piston P. Owing to lack of space the indicator cylinder proper is dispensed with and the piston moves in an accurately fitting hole provided directly in the wall of the cartridge chamber. The motion of the piston is transformed into the oscillations of the mirror M in the following manner. The mirror M is fastened into the holder E which in turn is supported in the middle of a steel strip S fixed at both ends to the frame of the apparatus. The other extremity of the holder E is connected—by means of the piece F and the hollow rod G—to the piston. Whenever the piston is moved (corresponding to the axial deformation of the tube springs) the mirror is tilted thereby and the supporting strip S is put under torsion. With the aid of the adjusting nut H the whole moving system is placed under a certain initial stress and thereby all backlash is eliminated. This is an absolute necessity with this instrument owing to the extremely small displacement of the piston. The inner tube is

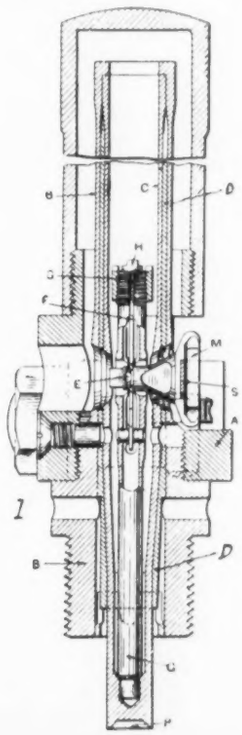
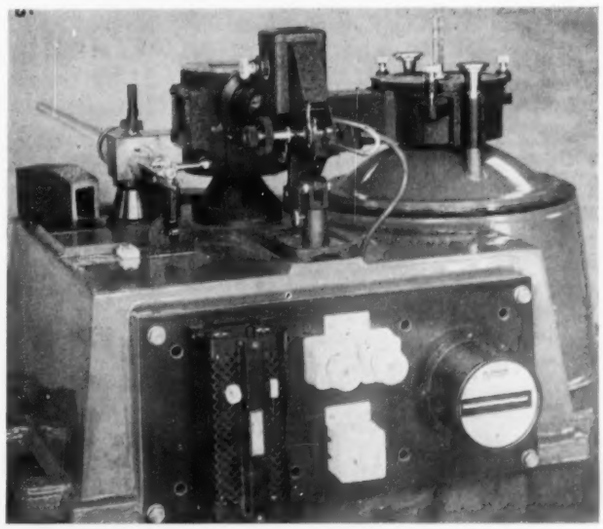


Fig. 97a. (left) Thring-Rumpff Indicator for guns. Fig. 97b. (below) Photo of complete Thring-Rumpff apparatus.



*Asst. Prof. of Engineering Research, Pennsylvania State College.

[23] The description is based on information supplied by Dr.-Ing. Hans Rumpff, Bonn, Germany.
C. M. Balfour. Pressure Measurement in Ballistic Research. *Engineering*, Vol. 134, Aug. 26, 1932, pages 231-232.

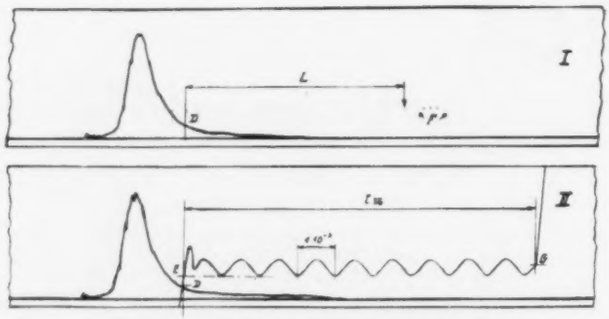


Fig. 97c. Diagrams taken with the Thring-Rumpff apparatus.

guided by a thin tube D along a large portion of its total length in order to avoid buckling under compression. The dimensions of the tube-springs are such that these are stressed almost to their elastic limit when the highest gas pressure is applied to the piston. This is necessary in order to have the lightest spring weight consistent with no permanent deformation, i.e. with the return of the piston and mirror to their initial position after the pressure ceases.

In the complete apparatus (Fig. 97b) the rifle barrel (shown at the left) is screwed into a massive steel socket. The pressure element described above is seated in this socket and the piston reaches into the interior of the barrel. A ray of light from an electric arc lamp (shown in the middle) is led through a suitable optical system (diaphragm, lenses and prism) to the indicator mirror M from where it is reflected onto a film drum driven by an electric motor. The film drum and its enclosing light-tight case are easily removable for the purpose of loading and unloading it in the dark room. An electro-magnetically operated trigger and an interconnected photographic shutter mechanism are provided for preventing an exposure longer than one or two revolutions of the film drum.

For the evaluation of the gas pressure diagram it is necessary to determine the instant at which the bullet leaves the muzzle. This can be accomplished by either an electric spark or by oscillographic recording.

In diagram I, Fig. 97c, the row of points at F is produced by the discharge oscillations in the secondary circuit of an induction coil at the instant the primary circuit is interrupted by the passing bullet rupturing a wire placed in its path at the muzzle. For design reasons it is impracticable to produce the spark directly above the light spot of the pressure indicator, therefore a fixed distance L has to be measured back from the position of the first spark in order to find the abscissa D corresponding to the time of the bullet exit. (In later instruments the spark is recorded directly underneath the diagram.)

By oscillographic recording a diagram as shown at II is obtained. (It is to be noted that the oscillograph loop is to be located horizontally because the recording drum rotates around a vertical axis.) Through the oscillograph loop flows an alternating current of high frequency (say 1000 cycles) produced by a small radio oscillator. The frequency of this current can be kept constant with an error less than $\pm$ 3/10000. Beside this alternating current, a direct current also is impressed upon the oscillograph loop, which flows through the wire in front of the muzzle. A second contact wire, or wire net, is arranged about 18 ft. from the muzzle, and is ruptured likewise by the passing bullet. As long as the muzzle wire is not ruptured the direct current deflects the light spot of the oscillograph below the width of the film, and consequently it is not recorded on the film. At the instant, however, in which the muzzle wire is ruptured by the bullet, the image of the light ray shifts into the range of the film width and describes on it the alternating current curve from E to G. At the instant in which the second circuit is broken (18 ft. from the muzzle) a further shifting of the position of the a.c. curve takes place and it disappears again from the range of the film width. The advantage of the oscillographic recording is that the time scale is determined directly by the known frequency of the a.c. curve which is drawn on the film. Therefore measuring the drum speed with the tachometer, a proceeding involving errors, is not necessary.

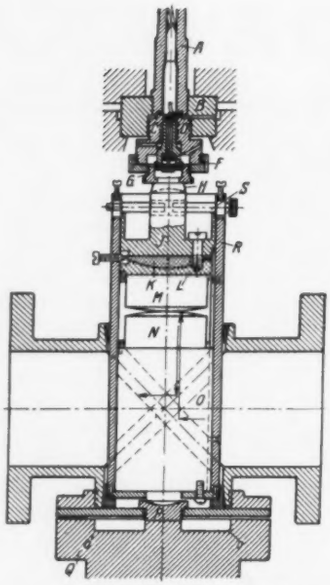


Fig. 98. Kirner's Ordnance Indicator. A, rifle barrel; D, accurately made plunger movable in its cylinder C. Freedom from leakage is attained with the aid of three grooves inside the cylinder. The forces are transmitted to lenses M and N.

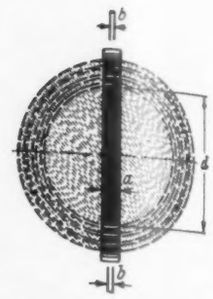


Fig. 98a. Interference rings of which only a diametral slice is used.

Fig. 98b. Diagram resulting upon a fast moving photographic plate, if the pressure undergoes a change.

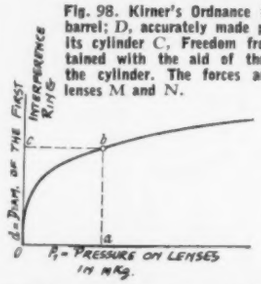


Fig. 98c. Calibration curve showing the diameter of the first interference ring as ordinate in the function of the static force exerted upon the lens in its axis, as abscissa.

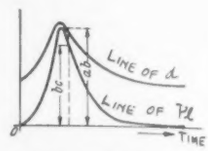


Fig. 98d. Evaluation of a curve originally obtained (diameter of ring) and the force (P_1) curve derived from it.

Based upon the principle of impulse:

$$v = \frac{\int P dt}{m}$$

and

$$s = \int v dt$$

the travel function of the bullet in the barrel can be determined from the diagram by two subsequent integrations.

In the gun indicator of the British Ordnance Research Department, Woolwich, England, designed by C. M. Balfour, a tubular rod in compression is employed likewise as a spring (Figs. 98 e and f). It is fitted with sliding fit in a steel block, which in turn is screwed into one end of the explosion bomb or gun. A copper washer fitted on a shoulder prevents the gas escape. The steel block is screwed down hard and it is not removed except in case of accident. The tubular spring is made of heat-treated "Vibrac" steel of high elastic limit. The outer end of the tube is of larger diameter and it is screwed

in against a copper washer. Fitted to the inner end of the tube is a thin piston of the same diameter turned in one piece with a long rod which passes through the tube extending just to the outer end. The piston is held in contact with the end of the tube by a short screwed length on the rod. Gas pressure acting on the piston compresses the tubular spring, allowing the end of the piston rod to project beyond its outer end. This projection which, so long as the elastic limit of the spring is not exceeded, is proportional to the pressure, is magnified optically by a mirror which reflects a beam of light onto a revolving drum carrying the photographic film.

The diameter of the tubular spring is 0.875 in. outside and 0.25 in. inside and its effective length is 8 in. Under a load of 60,000 lbs./in.^{2} the spring shortens by 0.0165 in. and this is magnified about 180 times. The natural frequency of the system is stated to be about 3800/sec.

Special attention is given to efficient sealing, for the propellant gases may attain a temperature of 3500° C. and when allowed to leak through a small aperture erode the metal and leave the surface too hard to be machined. Up to 10,000 lbs./in.^{2} the piston head can be protected with a layer of service luting, a plastic compound having a paraffin base, care being taken to exclude air. At higher pressures the sealing is accomplished by a small copper cup inserted into the bore and lightly expanded with a punch. Such a gas check is used only once, after which it is annealed and cleaned.

The optical recording system is carried on a steel ring which screws into a recess in the front part of the block. The mirror of stainless steel, 0.75 in. diam. is attached to the ring and to the piston rod by short lengths of flat steel springs as shown on Fig. 98f. This form of mirror mounting is free from backflash and friction and it offers little resistance to the piston movement, but a large resistance to movement in any other direction. The greatest angular displacement is about 1:60.

Another indicator for the investigation of fire arms has been developed by Kirner[24] which merits a description owing to the unusual principle it embodies. (Fig. 98.)

It is based on Newton's color-rings which are produced in a narrow, wedge shaped slit owing to the interference of light waves. The indicator consists of two glass lenses in contact, one of them being stationary while the other is capable of a minute displacement under the reaction force of the gun, or under the force transmitted to it by a plunger reaching into the powder chamber and subjected to the pressure of explosion. In the wedge-shaped space between the lenses color-rings are produced, the diameters of which increase if the lenses are subjected to pressure. An extremely small displacement of the lens brings about a considerable change in the diameter of the ring. This method has the characteristics of a very small displacement and practically no change of the adjacent space. The lens is covered except for a very narrow diametral strip through which only two short dashes, or strips, of the Newton rings are visible. Points belonging to the same ring lie at the same distance from the center of contact of the lenses. These points are photographed on a rapidly rotating photographic plate. If the pressure changes during the taking of the photo, a picture results as shown in Fig. 98b. The scale of pressures can be determined by a static test. The apparatus itself is shown in Fig. 98 in which A is the rifle-tube; D—a very accurately made plunger; J—lens holder; K and L are steel lenses for adjustment in order to bring the contact point accurately into the middle of the glass lenses M and N. (The radius of curvature is actually far greater than shown in the drawing.) The two glass lenses have to be mounted together in a dust free room, because the presence of dust interferes with the color-rings. O—lower lens holder with mirrors fitted into it for the entrance and exit of the light ray.

[24] J. Kirner. Optischer Interferenz-Indicator. (Optical interference indicator.) *Forschungsarbeiten der V.D.I.* No. 88, 1910, 48 pages.

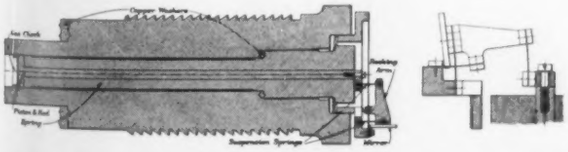


Fig. 98e. Gun indicator of the British Ordnance Research Department, designed by Balfour.

Fig. 98f. Diagram of mirror suspension in deflected position, of the Balfour gun indicator.

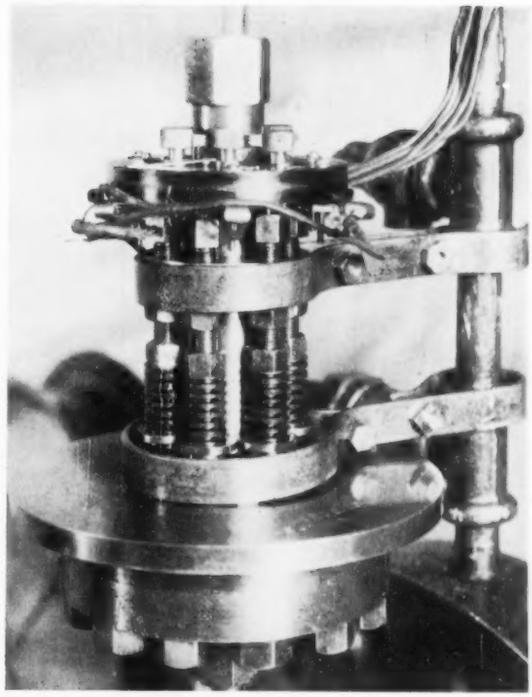


Fig. 99. Injection Pressure Indicator of Schweitzer (Pennsylvania State College) (latest design).

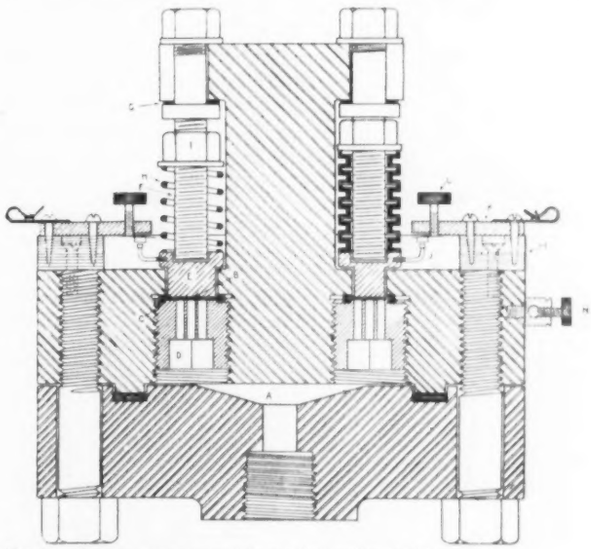


Fig. 99a. Pressure measuring unit in principal section (earlier design).

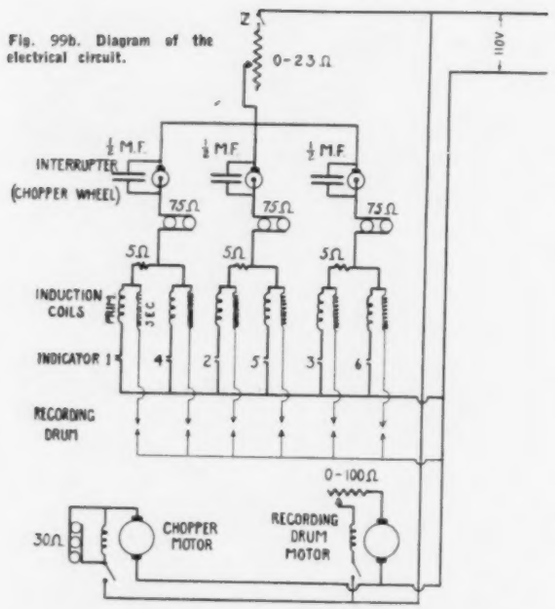


Fig. 99b. Diagram of the electrical circuit.

In the fuel injection system of a Diesel engine, pressures of several thousand lbs./in.^{2} are encountered, and rapid pressure changes take place in a short period of time. For investigating these pressure changes an indicator, originated by P. H. Schweitzer,[25] has been developed at The Pennsylvania State College (Fig. 99). The object is to keep the volume change small. A number of spring-loaded diaphragms are embodied, each spring being set to balance different predetermined pressures acting upon the diaphragm. When this pressure is attained the diaphragm is displaced by an extremely small amount (0.005 in.). Thereby an electric contact is established and a spark produced between a spark point and a rotating drum carrying a strip of paper, puncturing this latter. To each pressure element corresponds a spark point. During a pressure change, therefore, on the paper strip a number of spark rows are produced, which, by their beginning and ending record the period of time during which the pressure in the system exceeded that predetermined pressure to which that particular pressure element was set. The electric circuit is shown in Fig. 99b.

Ricardo has taken indicator diagrams from injection pipes with a "Farnborough" indicator with the aid of a pressure increasing device as described in a previous chapter.

Recently Dr.-Ing. Hans Heinrich, in cooperation with the Robert Bosch Co. in Stuttgart, Germany, has developed a stroboscopic method for the investigation of pressure fluctuations in the injection line of an oil engine[26] In the fuel line a pressure measuring element (Fig. 100) is interposed which consists of a small piston B (2 mm. dia.) loaded by a diaphragm A. The piston has an extension pin D upon its upper end which reaches into the field of vision of a microscope as shown in Fig. 100a. The indicator is calibrated before and/or after an experiment by means of an accurate pressure gage. The thickness of the diaphragm (actually 0.2 –0.6 mm.) is chosen according to the peak pressure to be encountered. There

[25] P. H. Schweitzer. Oil Pressure Indicator. *Oil Engine Power*, July 1927, pages 475-479.

[26] H. Heinrich. Vorgaenge in der Brennstoffdruckleitung kompressorloser Dieselmaschinen. (Injection-line phenomena in solid-injection oil engines.) Thesis for Doctor's degree. Univ. of Stuttgart, Germany. Abstract in *Dieselmaschinen V. of the V.D.I.*, 1932, Berlin, pages 143-148.

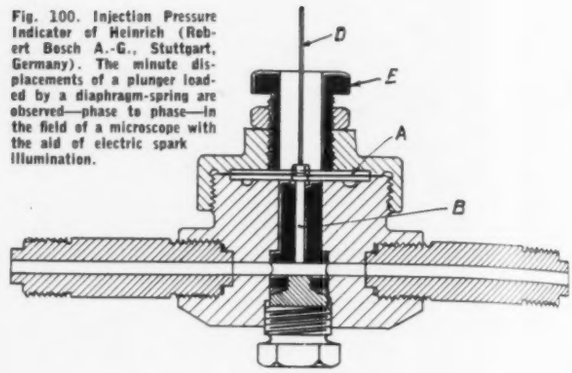


Fig. 100. Injection Pressure Indicator of Heinrich (Robert Bosch A.-G., Stuttgart, Germany). The minute displacements of a plunger loaded by a diaphragm-spring are observed—phase to phase—in the field of a microscope with the aid of electric spark illumination.

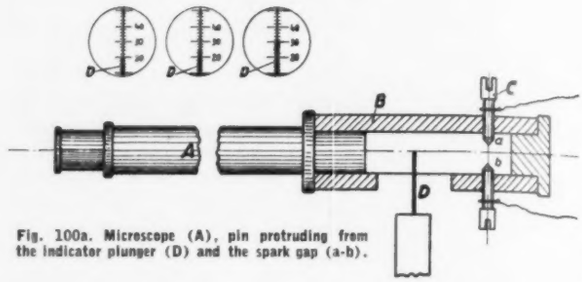


Fig. 100a. Microscope (A), pin protruding from the indicator plunger (D) and the spark gap (a-b).

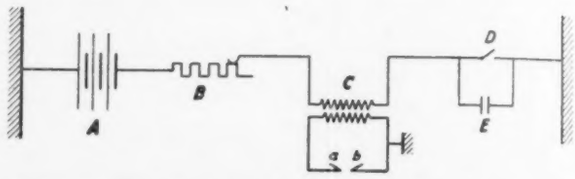


Fig. 100b. Diagram of the electrical circuit in which A is the battery, B is a variable resistance, C is a transformer, D is the interrupter in the primary circuit with a condenser E shunted across it to avoid sparking, and a-b is the spark gap in the secondary circuit.

being no mechanical or optical magnifying gear attached to the piston its period of oscillation can be kept very short. For the determination of the exact instant of the beginning of the pressure rise a very weak diaphragm is used. To prevent its fracture under the high pressures a hollow stop screw E is provided which limits the possible displacement of the diaphragm.

The field of vision of the microscope is provided with a finely graduated scale. It is illuminated by an electric spark passing through the gap in the secondary circuit of a transformer. The electric circuit is shown in Fig. 100b. The primary coil of the transformer is connected

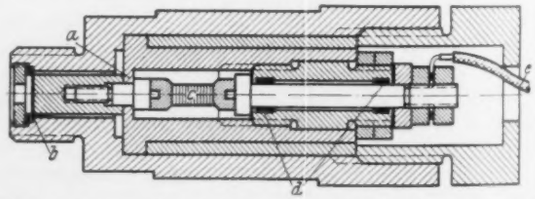


Fig. 101. Diaphragm—carbon pile indicator of Giamann, a main diaphragm (2 mm. thick, 11 mm. dia.); b flexible diaphragm for protecting the carbon pile from the oil; c carbon pile constructed of thin graphite disks; d insulation; e connection to circuit.

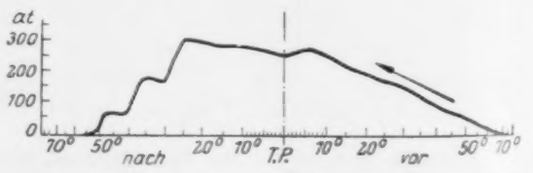


Fig. 101a. Offset diagram of an injection pump of a slow speed oil engine.

(Continued on Page 76)

MEASUREMENTS of CRANKSHAFT WHIP and VIBRATION

By M. M. ROENSCH*

CERTAIN phases of engine design have been severely handicapped by lack of accurate knowledge concerning the whipping and vibrational characteristics of crankshafts. A study of this subject was undertaken some months ago in the Engineering Laboratories of the Chrysler Corporation. At the outset, among several possible methods of procedure, an optical system of measurement, using stroboscopic illumination, was selected as being the most satisfactory. The General Radio Company's Type 548-A Edgerton Stroboscope was used for this work. The intensity of illumination, coupled with a short flashing period, produced a satisfactory image in the microscope at all operating speeds. Measurements were made with this equipment which would have been impracticable with stroboscopes having a longer period of flash.

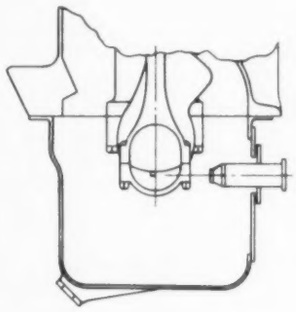


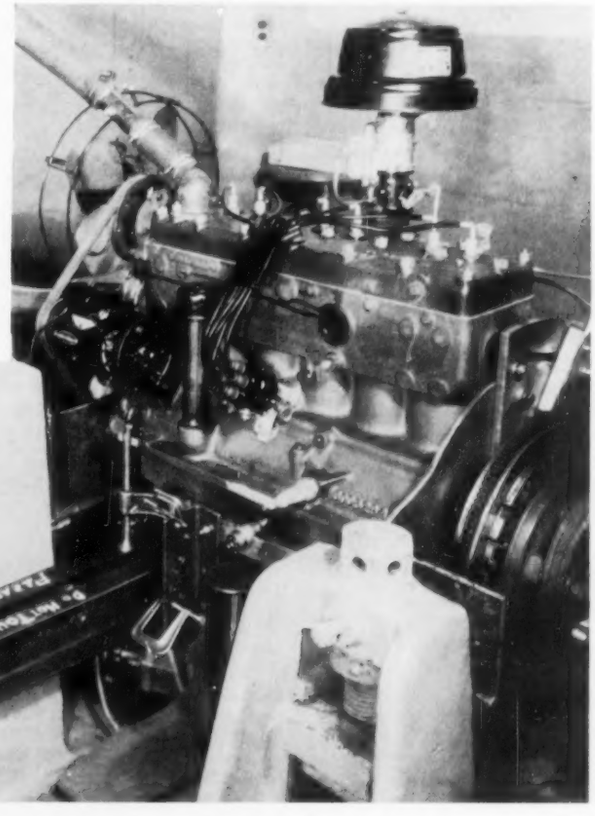
Fig. 1

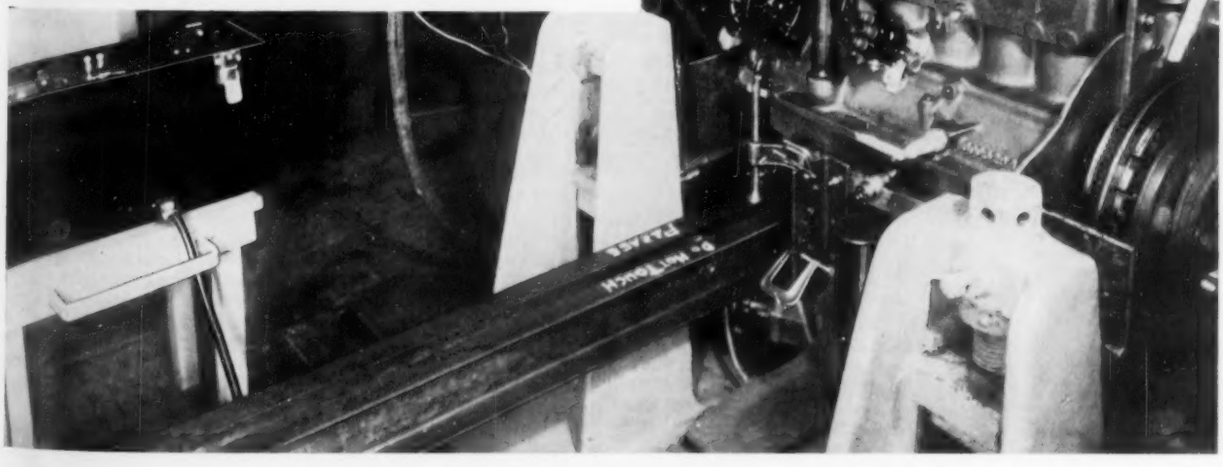
The accompanying photograph, Fig. 2, shows a general view of the apparatus set up for an examination of the deflection occurring at the center of an experimental 6-cylinder crankshaft under operating conditions. The deflection was measured by means of a microscope, fitted with an eyepiece micrometer, which was focussed on a reference mark on the head of a screw tapped into the crankshaft. The optical axis of the microscope was set up tangent to a circumference through the reference mark at the desired crankshaft angle as shown in the diagrammatic sketch, Fig. 1.

The shaft was illuminated by means of a stroboscope flashed in synchronism with the crankshaft by means of a spring contactor on the flywheel. The contactor may be seen—at extreme right of Fig. 2—mounted on a sector plate at the rear of the engine. The contactor could be shifted on the sector plate to adjust the phase angle of the image. The wires connecting the contactor to the stroboscope panel on the stand at the extreme left have been omitted.

The microscope was mounted on a structural steel beam supported from a point outside and insulated from the engine foundations as shown in the photograph. Since the microscope was mounted independently, the deflection of the crankshaft was obtained by taking the difference between the observed displacement of the crankshaft and that of its supports in the cylinder block. This system was adopted rather than that of mounting the microscope directly on the cylinder block, in order to avoid almost certain error due to vibration of the microscope and its mounting brackets with respect to the main bearings. The microscope on its independent beam support remained motionless, however, for all operating conditions. A close-up of the beam with the microscope in position in a hole cut out of the oil pan is shown in Fig. 3. The large opening cut in the oil pan was covered with celluloid to permit illumination of the crankshaft by the mercury vapor flash

Fig. 2





*Engineering Department, Chrysler Corporation, Detroit, Mich.

Fig. 3

lamp which is shown in position. The microscope was installed to clear the celluloid window so that engine vibrations could not be transmitted to the beam.

The oil spray in the crankcase proved to be a problem of major importance, for the slightest film of oil on the microscope objective rendered observations impossible, while the coating of oil on the inside of the celluloid window considerably reduced the intensity of the light from the stroboscope flash lamp. An oil shield was constructed to fit over the microscope, which, after a number of modifications, successfully prevented clouding of the objective and enabled observations to be taken over a fairly long period without having to clean the lenses.

The deflections at various points along the crankshaft axis were observed over a wide speed range and for a variety of engine loads. The results of the observations were then plotted to show the elastic deflection of the crankshaft for all observed conditions of load and speed. Since, in a 4-cycle engine, the working cycle is completed every 2 revolutions of the crankshaft, it might be expected that a blurred image would result if the stroboscope flashed in synchronism with the crankshaft. In these tests, however, the crankshaft was seen in 2 distinct positions so that the deflections on alternate revolutions were observed directly. If the stroboscope was flashed at half crankshaft speed, the shaft would have been seen in but a single position, thus requiring a second series of observations to be taken with the stroboscopic image phased around 180° in order to obtain the deflection on the second series of alternate revolutions.

Gas pressure has generally been considered to be a factor of minor importance in its effect on crankshaft vibration, especially in these days of high engine speeds, but a direct visual examination of its effects by means of the stroboscope indicates that this is a factor worthy of consideration.

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Notice

In The Handbook of Industrial Instruments on page 549 of the September 1930 issue of *Instruments* several references were made to a German book on humidity measurement. This book is Feuchtigkeitsmessung by Bongards, 329 pages, 126 figures, published in 1926 by Verlag R. Oldenbourg, Berlin. Cloth, price RM 15.30.

The Engine Indicator

(Continued from Page 74)

in series to a 12 volt battery, *A*, the variable resistance *B* and the interrupter *D*. A condenser *E* is connected across the interrupter in order to prevent arcing between the interrupter points. A cam on the rotating shaft of the injection pump actuates the interrupter which is mounted upon a disk coaxially arranged with the pump shaft and is capable of being rotated manually by means of a worm and worm wheel drive. In this manner the phase of interruption can be set to any desired point with an accuracy of 1/10 degree. In this predetermined phase the spark illuminates the field of vision of the microscope and the position of the indicator needle D can be observed. The length of spark is about 8 mm. (5/16 in.) corresponding to a secondary potential of 8000 volts. In this manner the pressure in the fuel line can be determined at each phase of the injection cycle.

An electric indicator for the high pressures occurring in the injection line of an oil engine has been developed by Glamann[27] using a stiff diaphragm for pressure element and an electric method, based upon the variable resistance of the carbon pile, for recording its deflection. The pressure element is shown in Fig. 101, in which *a* is the diaphragm (2 mm. thick, 11 mm. dia.) the deflections of which are communicated to the carbon pile *c*. The very flexible diaphragm *b* serves only for protecting the rest of the apparatus from the oil, its stiffness is negligible in comparison to that of the diaphragm *a*. The varying resistance of the carbon pile is recorded through a Wheatstone bridge circuit by an oscillograph in a similar manner to that used in the Martin and Caris indicator. (See Fig. 85.) An actual diagram is shown in Fig. 101a.

[27] H. Triebnigg. Untersuchungen an Pumpen und Brennstoffventilen fuer Dieselmotoren. (Investigations on injection pumps and nozzles for oil engines.) *V.D.I. Dieselmaschinen V.*, Berlin, 1932, pages 94-100. (Describes the "carbon pile with diaphragm" indicator of Glamann.)

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(Continued from Page 70)

tical use, and batteries were used in plating. He, therefore, began the study and construction of dynamo-electric machines, and in 1875 joined a firm manufacturing such machines. This business was incorporated in 1877 as the Weston Co., and was consolidated in 1881 with the U. S. Electric Light Co., of which Mr. Weston served as electrician until 1888. Mr. Weston's improvements in the field of dynamo construction caused phenomenal increases in the efficiency of these machines. He also invented new devices for starting, controlling, and protecting them. From 1875 to 1886, he did notable development work in both incandescent and arc lighting.

Encountering in all his researches great difficulty in making the necessary electrical measurements with the clumsy instruments then available, he developed and built for his own experiments a set of more practical instruments. His friends promptly wanted some of the same types. In 1888, he relinquished his other interests and established the Weston Electrical Instrument Company. Here, again, his knowledge of chemistry and his great ability in experimental research were needed in the development of alloys with practically zero temperature coefficients. Today, his alloys are used in virtually all kinds of electrical measuring instruments. In 1908, the Weston Standard Cell was accepted as the universal standard of e.m.f.

Mr. Weston was a Charter Member of the A.I.E.E., Manager 1884-87, President 1888-89, and Vice-President 1889-91. "In recognition of his distinguished services to mankind rendered in the field of pure and applied science," he was elected an Honorary Member of the Franklin Institute in 1924. He received honorary degrees from McGill University, Stevens Institute of Technology and Princeton University, and among other high honors, the Perkin Medal of The Chemists' Club, the Cresson Medal of the Franklin Institute, and the Franklin Medal, the highest award of that Institute.

Flow Measurement and Control**

By M. F. BEHART

CHAPTER XXIII
POSITIVE METERS
(Continued)

4. Weighing Meters

(b) Commercially Available Models

(Concluded from Dec. 1932 instalment)

Precision Weighers have been developed principally by automotive testing engineers and have given greater satisfaction in this particular field than have precision volumeters—which is to be expected because while the motoring public has been mis-taught by pseudo-scientific advertisements to think in "miles per gallon," engineers know better, express performance in B.t.u. consumption, and express the heating value of fuels in B.t.u. per lb. The A.S.M.E. Power Test Codes for Internal Combustion Engines (which Codes are not limited to the automotive field) specify that "liquid fuel . . . should never be measured by volume; it must be weighed directly as used." Similar provisions are found in other official specifications.

The majority of precision weighers are non-commercial. They are purely laboratory devices unsuitable for industrial service and therefore not to be described in this book. Most of them require a good deal of manipulation not only before use but in use, and do not even look like meters, being unprovided with counters. That they are called "weighing machines" rather than weighing meters may be due to such official bans as the A.S.M.E. Code's paragraph 29 which reads "In no case shall meters be used to measure liquid fuel supplied to an engine." This was no doubt meant to forbid only volumetric meters, and we may mention on the other hand that other authorities *encourage* the use of meters (weighing or volumetric, so long as they are dependably calibrated) for measuring fuel consumption. Only one precision weighing meter is reported at this writing (1933) to be commercially available and its detailed description follows.

The *Roesch Precision Weigher**, Fig. 23-7A, has some ten years of successful use in several mid-West laboratories and requires so little manipulation that it (or a modification of the model illustrated) appears to qualify for industrial plant service. Mounted on casters, it may be moved from place to place but it is not a portable meter and cannot be used in a moving vehicle. In common with most precision weighers it lacks an easily-read register such as industrial meters generally possess. On the other hand it may be used to determine gravimetric rate of flow (in pounds per hour or in other desired units of weight and time.) Quantities are successively isolated, so that this is truly a positive meter; these quantities are weighed on a sensitive balance, so that the limit of error is well within precision requirements.

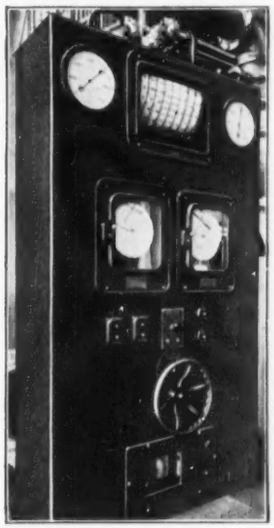
On the right arm of a sensitive beam scale mounted on knife edges is hung a glass container, which supplies the metered fluid to the engine being tested or to any other device using liquids in amounts within the capacity of the meter. On the left arm of the beam scales is hung a counter-weight. The glass container is intermittently supplied with fuel from the copper reservoir at the top. (This reservoir has two compartments so that either of two liquids is available by manipulation of proper stopcocks.) The glass container is automatically held at nearly an even balance by a solenoid-operated valve which intermittently supplies fuel from the main reservoir. With the master control switch (shown on the box at the left of the instrument) thrown to the right, this intermittent feed to the glass container will continue as long as the engine uses fuel. Tests can be started at any time that the valve is not supplying fuel to the glass container, *i.e.* when the glass container side is heavy. The test is started by throwing the master switch to the left. As the glass container becomes lighter it rises to an even balance with the counter-

*Developed by Professor Daniel Roesch, Armour Institute of Technology, and now commercially available, but at this writing no Roesch meters are "carried in stock for immediate shipment," as is the case with commercial liquid meters in general.

**Part Six of *The Manual of Instrumentation*.

†Engineering Editor.

FOR BOILER CONTROL



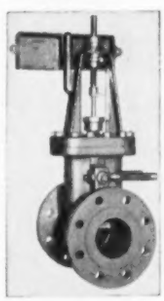
THE BAILEY BOILER PANEL gives complete information for controlling boiler operation. It contains the Bailey Boiler Meter, a Bailey Fluid Meter with which is combined a Boiler Water Level Recorder, and a Bailey Multi-Pointer Gage. The operator has everything right before him to obtain the desired capacity and best efficiency at all times. Request recommendations for your boilers.

PRESSURE GAGE

Extremely accurate gages embodying the dead weight gage tester principle are available in several sizes up to 36" in diameter for indicating at remote points the pressure of steam, water, gas, etc. These gages can be used with any pressures and are particularly suitable for magnified ranges. Ask for Bulletin No. 70.

LONG DISTANCE INDICATOR

Bailey Meter Selsyn Operated Equipment for recording and indicating pressure, temperature, draft, liquid level, etc. at any distance from the source is highly accurate and reliable. Described in Bulletin No. 110.



ADJUSTABLE ORIFICE

The Bailey Adjustable Orifice is for use with Fluid Meter installations where accurate measurements are desired over a flow range of as wide as 160 to 1. Ask for details.

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MANUFACTURERS' LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

A59 **Dial Gauge.** Circular describing a dial thickness gage for paper, rubber, sheet metal, glass, wire, etc. B. C. Ames Co., Waltham, Mass.

A60 **Magnet Wire Testing.** Circular describing apparatus for testing the springiness of magnet wire. Morehouse Machine Co., York, Pa.

A61 **Tube Tester.** Circular describing a tube tester which tests all new tubes as well as old ones without adapters. Radio City Products Co., 48 West Broadway, New York.

A62 **Coil Meters.** A circular describing precision electrical instruments. Beede Electrical Instrument Co., Penacook, N. H.

A63 **Recording Instruments.** "Practical" recording instruments, for use outside the laboratory, are described in a circular issued by Recording Instrument Sales Co., 8 South Michigan Ave., Chicago, Ill.

A64 **Relay.** The Dunco Mercury Swing Type Relay manufactured by Struthers Dunn, Inc., 139 N. Juniper St., Philadelphia, Pa., is described in a leaflet identified as P32-11-32.

A65 **Stop Watches.** A reprint from the Railway Magazine describes the new range of stop watches manufactured by Messrs. Arnold & Co., 17 Elmcroft Ave., Golders Green, N. W. 11, London, England.

A66 **Resistor Units.** Circular 507 describes Vitrohm radio products. Ward Leonard Electric Co., Mount Vernon, N. Y.

weight and closes the mercury contact near the lower part of the center post of the beam scale. This contact carries the primary current of a relay and a current of about 1/10 amp. The secondary of the relay starts the stop-watch. At any time after the watch is started and before the end of the run the desired weight is added to the pan under the glass container. This makes the right side of the beam go down, where it remains until a weight of fuel, equal to the selected test weight, is used by the engine. A second rising of the glass container again operates the platinum-mercury contact and stops the watch. This records the time necessary to use the selected weight of fuel. After noting the time as registered by the stop-watch, the master switch is opened and then

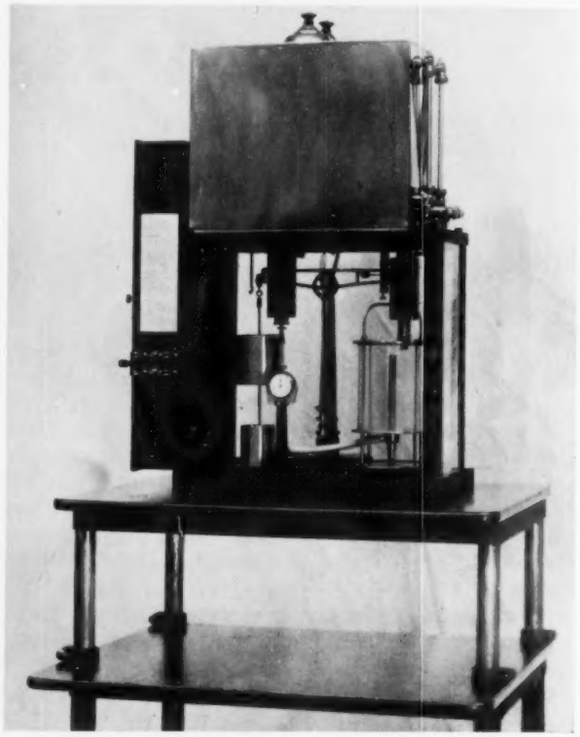

Fig. 23-7A

closed again to the left in order to reset the stop-watch to zero. The master switch is then thrown to the right and the test weight removed from the pan. This will refill the glass container with the fuel used during the test and thereafter maintain the level and balance so that the meter is again in readiness.

The actual operation of the meter requires little time, as is indicated by the following instructions for operating:

"*For Automatic Filling:*

"Throw Master Switch to the Right.

"*For Testing:*

"(1) Throw Master Switch to the Left whenever Glass Reservoir is not filling.

"(2) After Watch Starts, place desired Weight on Pan.

"(3) At End of Run, read the Watch and Revolution Counter.

"(4) Open Master Switch and Close again to Left. This resets watch.

"(5) Throw Master Switch to Right and remove Weight from pan in readiness for the next test."

The weights used for testing are placed on the same side of the beam scale as the glass container for the fuel. This arrangement prevents errors due to unequal lengths of balance arms which may be caused by knife-edge wear or otherwise. The personal element of reading fuel levels, starting watches and reading flow meters is done away with since the beam scale movement closes the electrical circuit which operates the stop-watch and counter. The beam is subjected to the same weight at the beginning and end of the run and hence is subject to the same inertia effects and sensitivity for the beginning and end of the run. Runs of 30 seconds to one minute may be made with a fuel determination error of approximately 0.5%. Runs may be made for any weight of fuel from 0.025 lb up to 1 lb or more by increments of 0.025 lb. This entire range is provided for by six test weights (which have been standardized on chemical balances). This range of weights permits adjusting the time of a test run as desired.

When the master switch is thrown to the right the meter holds itself in readiness to test by intermittently feeding fuel to the glass container in amounts corresponding to approximately $\frac{1}{16}$ to $\frac{1}{8}$ inch variation of level. The *maximum* time necessary before starting a test will be that required to use this amount of fuel. The operator's time is not, however, required since he can throw the master switch to the left and the fuel test will start automatically at the proper time. The weight is placed on the pan at any time before the conclusion of the test run. The fuel test will then stop automatically and the readings can be made at the convenience of the operator.

". . . The primary electrical contact of platinum and mercury is made by an ingenious arrangement which permits of a long horizontal motion and positive break of the plati-

num tip. The mercury is forced vertically out of a long thin slot which is at right angles to the motion of the platinum tip. The height of the mercury can be readily adjusted by means of a thumb screw. The entire break can be covered with kerosene or light oil to give an oil switch effect when testing with highly volatile fuels. Such precautions have not ordinarily been considered necessary with motor gasolines. The gasoline supply to the glass container is open so that it can be seen. This does away with the uncertainty of leaks when using a three-way cock between the general fuel supply, the test supply and the engine feed. The valve just above the glass container closes without dripping, thus insuring correct successive weighings."

POSITIVE GAS METERS

8. General Considerations

(a) Definitions, Gas Laws, etc.

In order to make the best selection—from practical as well as theoretical viewpoints—of a gas meter for any given industrial processing application, and to "get the most out of it," it is well to take into account the physical and chemical properties of the particular gas or gas mixture to be metered. These will depend on composition (of gaseous constituents including superheated vapors); on cleanliness, i.e., freedom from solid particles and/or droplets of tar or similarly heavy and gummy substances; and on purity, i.e., freedom from fogs resulting from cooling below the dew points of vapors. A "wet" gas is not necessarily one which contains more than a definite quantity of water vapor per unit of volume but it is one accompanied by saturated vapor and/or containing free moisture.

The properties of the metered gas *at the metering point* should be determined if possible, or calculated in advance as when designing, or at least estimated with a margin of safety. For example a gas mixture may be dry as it leaves the top of a fractionating tower but the metering point may be so remote and in such a cooler location that as the gas enters the meter it carries a considerable quantity of entrained liquids, if not particles of tar, etc.

Also in this connection it is well to bear in mind that all industrial gases, under extreme conditions near their liquefaction points, cease to be true gases and become vapors, and that they obey the laws of perfect gases only approximately. (The deviations are usually small. Where they are large, as in the case of ammonia, carbon dioxide, etc., the user of this book no doubt has obtained special tables or graphs applying to his particular process, so that this subject need not be treated in detail.)

Positive gas meters without accessories simply measure volume; their registrations are meaningless without knowledge of pressure and temperature. There are gas meters with automatic compensation devices for pressure and temperature (and even for density). Most of these are inferential but some are positive and will be described in this chapter.

When gas is flowing in a circuit and through a meter the only definite quantity which remains constant is the *weight*, and, as Eason points out, even this will only remain constant as long as there are no leaks and no condensation on the walls of the circuit. In practically all uses of gases the quantity of interest to the user is the weight—not the volume, hence the necessity of reducing volumetric measurements to standard units such as the legal cubic foot defined by government agencies for regulating gas companies, or—in laboratory work and in some chemical industries—the cubic milliliter at normal temperature and pressure (n.t.p.). When gas flows through any meter, the pressures, temperatures and specific volumes at the inlet differ from those at the outlet. The difference is usually small, sometimes quite negligible as when the measured flow is a small fraction of the rated capacity, but sometimes considerable as when a meter is "raced." Nevertheless, exactly the same weight of gas passes out of the outlet as enters the inlet unless a change of state takes place; moreover there is very little slippage in most dry types of gas meters and none in the wet types, so that although any gas meter—even a perfectly positive meter—may be inaccurate by reason of improper calibration, few exhibit "errors of uncertainty." In other words *variance* is seldom met with.

Fundamental laws and formulæ pertaining to fluid measurement, and especially to gas measurement, have been given in Chap. XXII. Useful tables and detailed discussions on specific subjects are relegated to the Appendix. The 72-page chapter on "Properties of Gases and Vapors" in Vol. I of *Experimental Mechanical Engineering* by Diederichs and Andrae is recommended to mathematically grounded readers as an additional reference, and for the solution of special gas measurement problems other references in our appended bibliography may prove of immediate value. At this point we merely insert, as a reminder, a brief summary of the fundamental data.

A67 **Rheostats.** Bulletin 1103 features the Vitrohm coil type rheostat with a fine continuous adjustment. Ward Leonard Electric Co., Mount Vernon, N. Y.

A68 **Adjustats.** Bulletin 1104 on Vitrohm adjustats designed for use with fractional horsepower motor speed control, radio, and with laboratory and miscellaneous equipment. Ward Leonard Electric Co., Mount Vernon, N. Y.

A69 **Resistance Box.** Directions for the use of a "Determ-Ohm" Resistance Box. Ohmite Manufacturing Co., 636 North Albany Ave., Chicago, Ill.

A70 **Circuit Breakers.** Catalog No. 6 describes Type O indoor oil circuit breakers. Roller-Smith Co., 233 Broadway, N. Y.

A71 **General Radio Experimenter.** Vol. VII, No. 8 of this publication features the article "Recent Developments in Mica Condensers." General Radio Co., Cambridge A, Mass.

A72 **Water Regulating Valves.** Bulletin 696 describes the Cochrane Pilot Actuated Water Regulating Valves. The Cochrane Corp., 17th St. and Allegheny Ave., Philadelphia, Pa.

A73 **Tintometer.** 8-page booklet describes the Lovibond Tintometer, an instrument for measuring color. The Tintometer Ltd., The Colour Laboratory, Milford, Salisbury, Eng.

A74 **Controls.** Circular issued by the Leland Electric Co., Dayton, Ohio, on time and sequence controls for industrial processes and general applications.

A75 **Tape Rule.** A circular describing "All Stainless Crescent" tape-rule. Lufkin Rule Co., Saginaw, Mich.

A76 **Manometers.** Loose leaf Bulletins 1320, 1321, and 1324 describe direct reading manometers. Bacharach Industrial Instrument Co., 7000 Bennett St., Pittsburgh, Pa.

A77 **Fuses.** Littelfuse Laboratories, 1772 Wilson Ave., Chicago, Ill., have issued a 7-page circular on where and how to use low range and high voltage fuses.

A93 **Humidity Indicator.** Bulletin No. D describes and illustrates a hair hygrometer. Julien P. Friez & Sons, Inc., Baltimore, Md.

A94 **Feed Equipment.** Circular on a chemical feed device to feed even the most corrosive chemicals. Phipps & Bird, Inc., 140 Virginia St., Richmond, Va.

A95 **Moving Coil Instruments,** are described in a single sheet circular issued by the Triplett Electrical Instrument Co., Bluffton, Ohio.

A96 **Control Assemblies.** Bulletin #B describes complete control assemblies for air-conditioning fields. Julien P. Friez & Sons, Inc., Baltimore, Md.

A97 **Industrial Instruments.** Recently issued booklets, catalogs, circulars and instruction sheets (in French) pertaining to indicating, recording and registering instruments, featuring water, oil, gasoline, gas and electricity meters, fire- and lightning-protection devices, electrical instruments, optical pyrometers, electro-magnetic tachometers, automatic flue-gas analysis recorders, etc. Compagnie p. Fab. d. Compteurs & Matériel d'Usines à Gaz. Montrouge, Seine, France.

A98 **Moisture Tester.** Pamphlet issued by the Alpha Lux Co., 192 Front St., New York, describes the "Speedy" Moisture Tester used for testing sand, gannister, coal, coke, coal dust, oxide, powdered fuel, etc.

INSTRUMENTS, 3619 Forbes St., Pittsburgh, Pa.

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

.....

.....

Name.....

Position.....

Firm.....

Street and No.....

City.....State.....

INSTRUMENTS BOOK SHELF

Lampworking (Lehrbuch der Glasbläserei). By Carl Woytacek. Second Edition. Julius Springer, Vienna. 309 pages, 624 illustrations. Cloth, 6 x 9 inches, price, 22.50 gold marks.

As its title suggests, this book describes the various means, methods and equipment necessary for the transformation of the laboratory technician into a lampworker. It consists of many sections, each of which is devoted in minute understandable detail to a specific subject. The first covers glass in general, and is followed by a section devoted to glass composition with particular reference to the general characteristics of the 3 glasses used principally for lampworking—soda, lead and borosilicate glasses. Conditions under which glass can be worked are also described. In subsequent sections, detailed description of an assortment of tools, equipment and material is given whereby a worker can adapt his equipment and tools to the varying conditions and fuel in various localities.

Correct methods of making various pieces of apparatus are accurately described and practically all operations involved in the fabrication of scientific glassware are included. Description of simple operations, such as pulling points, blowing bulbs and making splices, lead up to methods of making such intricate apparatus as diffusion pumps, X-ray tubes and vacuum gages. Interchangeable ground joints, which are now standardized, are not mentioned, nor are the methods of sealing metals and porcelain to glass described. It would seem that these worthwhile subjects are of sufficient importance to warrant inclusion for the benefit of advanced research workers. Cold stage working, such as drilling, etching and grinding glass, is amply described. Thermometer and hydrometer making are also described.

Throughout the entire book, the "theme"—*Keep your glass clean*—is emphasized, which is a point neglected by many lampworkers and not sufficiently brought out in most works on the subject. The book is well written and is probably the most complete in detail of any book so far offered on this subject. It is recommended to those who can read German.

—Herman H. Schrickel (11)-B-

The Microscope (Ultra Violet Edition). By Simon Henry Gage. The Comstock Co., Ithaca, N. Y. 589 pages, cloth, 6 x 9 inches, price $4.00.

This is the fifth edition of the authoritative book by the master of the biological microscope, Prof. Gage of Cornell University. With this edition, the text has been revised and entirely reset; many of the older, obsolete illustrations have been replaced by more modern cuts showing the more up to date instruments. Like the previous editions, it treats almost entirely of the bright-field biological type of microscope and its modifications such as the dark-field, the polarizing and the spectro-microscope, leaving all but brief mention of the other types of 'scopes, like the chemical and metallurgical, to the treatment already afforded them in the companion volumes of the "Handbook of Chemical Microscopy" by Drs. Chamot and Mason, also of Cornell (See *Instruments*, Vol. 3, No. 2, and Vol. 4, No. 5).

The greatest change has been the inclusion of a new chapter by the author's son, Dr. H. P. Gage, on the ultra-violet microscope and its use in physical analysis. This treats of the mechanics and optics of the so-called ultra-violet microscope (perhaps more properly called the fluorescence microscope) as well as its use as a research instrument. The use of the term ultra violet as applied to a microscope with only the substage optics transparent to ultra violet light, again brings up the controversy over terminology. The tendency today seems to be toward

Absolute Pressure is expressed in any units, but always with perfect vacuum as the zero point. It is the algebraic sum of gage pressure and barometric pressure.

Gage Pressure is that which is indicated by open-end liquid column manometers and by Bourdon and other such elastic-member gages. In all these instruments the measured pressure acts on one side, and the atmosphere on the other, of the pressure-responsive element. When such gages are not connected, the same pressure acts on both sides and they read zero: A gage reading zero in the open will still read zero if placed inside an evacuated vessel. Gages therefore indicate the difference between the absolute pressure to which they are connected and the atmospheric pressure around them. Should "two pounds gage" be maintained automatically in a piece of equipment while the barometric pressure is 14 lb per sq. in., the absolute or actual processing pressure will be 16 lb. Should the barometric pressure rise or fall, the processing pressure will rise or fall correspondingly because the pressure-responsive element of the usual automatic device is subjected internally to the controlled pressure and externally to the atmospheric pressure. Thus, except for rough work or in the case of pressures so high that barometric fluctuations are negligible, the corrected barometer reading must be added whenever the absolute pressure is the condition of importance. In many closed systems, however, the gage pressure is itself the important factor regardless of the barometric pressure. Thus in the case of gas to be supplied at a pressure of 4 oz. per sq. in., regulators are of the "gage" type and not of the "absolute" type, because 4 oz. gage pressure is specified.

Line Pressure, whether absolute or gage, is the *static* pressure, that which would be measured by an instrument at rest with regard to the stream (See Chap. XVI, §2). Only in the case of a line carrying high-pressure gas at high velocities do errors creep in by reason of kinetic effects. In such cases it may be necessary to take the precautions detailed in Chap. XXV, §11.

Pressure Base and Base Pressure. Since the actual quantity of any gas supplied or utilized varies not only with its volume but with its absolute pressure and inversely as its absolute temperature, a Pressure Base (usually expressed in oz. per sq. in.) must be specified. Calculations are made by adding the pressure base to the atmospheric pressure, the value of which must also be specified.

Density is the quantity of gas per unit volume.

Specific Gravity is the ratio of the density of a gas to that of dry air at the same pressure and temperature.

Boyle's or Mariotte's Law. At constant temperature, the product of the pressure and volume of a given quantity of a perfect gas is a constant.

$$PV = K_1$$

When the volume occupied by this given quantity (or weight) increases, the pressure decreases, and vice versa. The value of the constant K_1 depends on the particular gas, on its temperature and on its quantity.

Charles' Law is expressed in two ways:

(*a*) Volume being constant, the pressure equals the product of the temperature and of a constant.

$$P_v = K_2 T$$

The value of the constant K_2 depends on the gas, on its weight and on the constant volume it occupies.

(*b*) Pressure being constant, the volume equals the product of the temperature and of a constant.

$$V_p = K_3 T$$

The value of the constant K_3 depends on the gas, on its weight and on the constant pressure maintained.

From these laws it follows that for any given quantity of gas undergoing any changes of volume, of temperature or of pressure, PV/T will be a constant. The value of this constant, K_4, depends only on the gas and on its weight. The equation

$$\frac{PV}{T} = K_4$$

is the summarized expression of "the gas laws." Note that the value of K_4 depends only on the particular gas and on its weight, being proportional to its weight. This permits deriving a constant, R, depending only on the particular gas: $R = K_4/w$. Using this constant R, we can write

$$\frac{PV}{T} = wR$$

but the usual form is

$$Pv = RT$$

in which w equals unity and is dropped; and in which v is therefore the specific volume of the gas. This is the equation of state or characteristic equation for a perfect gas. See Chap. XXII.

In industrial work, where pressures are higher than those in domestic lines, Boyle's Law is the most important. The reason is that variations in gage pressure correspond more closely to variations in absolute pressure. Thus with an average barometric pressure of 14 lb per sq. in., a drop in line pressure from 154 to 138.6 lb per sq. in. would mean a 10% drop in the quantity-rate for the same uncorrected volume-rate, whereas in a domestic application a drop from 4 to 3.6 oz. per sq. in. (10% on the gage) would mean a drop from 14.250 abs. to 14.225 abs. or a decrease in the quantity-rate of less than 0.2%.

The thermodynamic zero of temperature being relatively "far," temperature fluctuations in gas lines—except between summer and winter extremes at outdoor metering stations—are of less consequence, and where gas is metered at room temperature the readings of a positive meter need only be corrected by applying Charles' Law where precision is desired.

9. Dry Types of Gas Meters

(a) Rotary Type

Under this heading most of the texts on engineering measurements include "rotary gas meters" with velocity-impelled rotors. These are not positive meters but current meters, see Chap. XXIV. We are only concerned here with positive rotary meters. The *Connersville* (Roots-Connersville-Wilbraham) is selected as sole type example because others, at this writing, are of comparatively

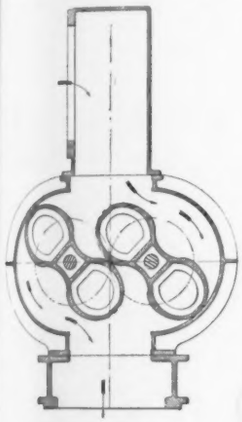

Fig. 23-67

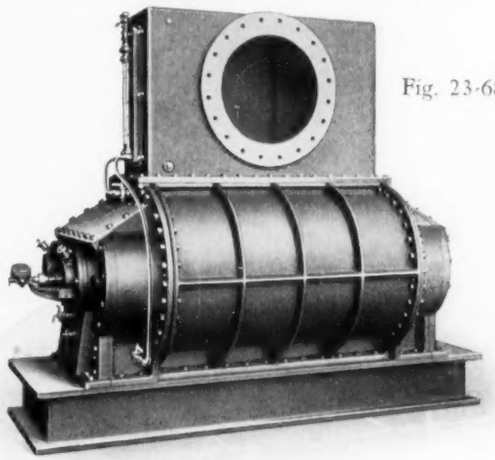

Fig. 23-68

insignificant industrial importance. Patented in 1924 and first called "Roots Meter" (by which name it still is called by many), it was originally designed only for measurement of low-pressure, clean, dry illuminating gas, but it is now built in different models for a wider range of industrial applications. The sectional drawing, Fig. 23-67, shows the principle; an adaptation of the Roots positive blower. It is a compromise between perfect sealing and no pressure loss. A meter of this type, to be perfectly positive at extremely low rates of flow, would obviously have a high absorption curve. Precision machining is the solution of the problem: the two rotors do not come in contact with each other (being timed by two pairs of gears, one at each end) or with the casing. Thus Connersville meters are not perfectly positive, but clearances are small and the slippage is negligible in normal use; while the moving parts are so light in proportion to the areas acted upon that the pressure loss is surprisingly low. Most sizes of these meters require a pressure drop of around 0.12″ of water at 10% of rating, less than 1″ at capacity flow, and about 1.7″ at peak (150%) load. The flow range of correct registration usually extends from around 15% to nearly 150% of the rating. The makers furnish on request curves of under-registration at low flow rates, permitting corrections to be applied. A typical curve of this sort shows the following percents to be added:

At 2% of rating, add	3.0 %	At 7% of rating, add	0.83%
At 3% of rating, add	2.0 %	At 8% of rating, add	0.65%
At 4% of rating, add	1.55%	At 9% of rating, add	0.55%
At 5% of rating, add	1.25%	At 10% of rating, add	0.45%
At 6% of rating, add	1.02%	At 12% of rating, add	0.30%

calling such a microscope a fluorescence microscope, and leave the term "ultra violet" to be applied to one with all quartz or other ultra violet transparent lenses. After all, the main use of the former is to study fluorescent properties; it cannot be used for truly ultra violet work such as ultra violet photography.

The other chapters of the book deal with interpretation of appearances, magnification and micrometry, drawing and enlargements, projection and photography and the technique of preparing and storing of microscopical preparations.

The reader might wish that the illustrations had been prepared with a little more attention to detail of lettering and numbering. In several cases, letters given in the legend for one illustration actually apply to another, while the illustrations themselves do not always carry their identification numbers. However, on the whole they are quite readily understood.

The collection into one table in the appendix, of the indices of refraction of the various immersion materials referred to throughout the book as well as those listed on page 190 might be a convenience welcomed by the average microscopist who would use the book for reference after the first reading.

Written by one who has spent more than fifty years with the microscope at his side, the book will be welcomed as an authoritative guide book to the use of the biological microscope and its modifications. The microscopist will find a wealth of information on tried and proven methods, and also numerous suggestions as to new uses of the microscope and procedures to be followed.

ARTHUR SCHRODER (7.7)-B-

Directions for the Use of the Askania Torsion Balance. Prepared by C. A. HEILAND for the American Askania Corporation. Maple Press Co., York, Pa., 1933. Cloth, 88 pages, 6x9 inches. Price $3.30.

As its title indicates, this little book is primarily a manual for torsion balance field operators. By using it carefully and intelligently, a man who is reasonably competent at handling instruments but with no previous experience with a torsion balance could probably take an Askania instrument into the field and make reliable measurements.

The theoretical treatment, although brief, is mathematically simple and straightforward and gives a clear picture of the source of the small forces which are measured by the torsion balance and how they depend upon irregularities in the field of gravity. The chapters on the computation of results from the instrument record (photographic plate) and on the computation of surface corrections are very complete, including several sample computation forms and numerical tables of the usual Schweydar terrain correction coefficients. Other less common methods of calculating terrain and cartographic corrections are given briefly but in sufficient detail so that they could be applied if studied diligently.

Directions for the actual manipulation of the instrument (both the Z-beam and large type) are given in detail, including the routine operations for individual stations and the special operations, such as changing the torsion wire and re-adjustment of the instrument. A chapter on field work, selecting stations, making terrain surveys, etc. covers the common operations and includes several cuts showing field equipment being set up, loaded on an automobile or truck, etc. Some of the essential auxiliary details such as securing station permits and a position survey to properly locate stations on a map are not mentioned.

A page on costs of torsion balance work, with an average of $10.00 per station for a 2-instrument party, is probably much too optimistic for the general run of torsion balance field operations.

The book covers the routine part of torsion balance work between the selection of a general plan of survey and the plotting of the measured values on the map. The chapter on inter-

pretation makes no attempt to cover the subject and is too brief (6 pages) to be of more than very elementary value. Its principal usefulness is a convenient formula for the calculation of regular, 2-dimensional features.

While the book covers reasonably well the routine operations, it gives the impression of having been prepared by one whose acquaintance with the details of torsion balance work is second-hand. An example is the statement (page 50) that "Isogams . . . . . appear as contour lines of the heavy masses." How simple and direct the interpretation of torsion balance work would be if this were only true!—L. L. NETTLETON (10)-B-

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Industrial Electric Heating. N. R. STANSEL. John Wiley & Sons, Inc., New York, 1933. Cloth, 6¼x9¼ inches, 444 pages. Price $5.00

Stansel's method of attack upon a problem in electric heating is to survey the process to be carried out from the point of view of the chemical and physical requirements and limitations, and from these to engineer the equipment that will serve those needs. Hence, there is straight-to-the-point discussion of heat transfer, effect of heat on metals, effect of furnace atmosphere, electrical properties of furnaces, etc., which, though aimed at electric furnaces in particular, is good fundamental heat engineering and valuable to many who may not be directly interested in electric furnaces. The points are driven home by specific examples of typical furnaces and their application, but so deftly is this done that minor details germane only to a single application are pretty much avoided and each example serves to bring out general truths. The illustrations and curves are well chosen. Each one clarifies the text. The engineer who studies the book will therefore not find his mind cluttered up with a mass of useless details, but instead will obtain a good foundation of essential principles, widely applicable, and will be led to sound methods of thinking. It is not a college text book nor a handbook of data, but is extremely well fitted for the self-improvement of the graduate engineer up against heating problems.

The book is gratifying free from sales propaganda harping on the superiority of electric over fuel-fired furnaces. The final chapter discusses some of the elements of an economic choice among furnaces, and of course, the fitness of the electric furnace for given types of service is brought out all along, but in general the assumption is made that the furnace user is seeking a result best obtained by electric heating and one that will stand the first cost, and the discussion proceeds from there.

The book does not cover everything that its title might include. It does not deal with the lowest temperature ranges, such as those involved in curling irons, core ovens, etc., nor does it deal with ferro-alloy production. Many of the principles discussed are, of course, applicable to the subjects not covered. The subjects dealt with are primarily those in which the greatest number of industrial furnace users are concerned.

Batch and continuous resistor furnaces of types suitable for heat-treatment of steel, annealing of non-ferrous metals, enameling, annealing of glass, etc., are well covered. Metal melting is dealt with from type metal up through brass and steel, involving rather thorough treatment of external and submerged heating units, direct and indirect arc furnaces, vertical ring and high frequency induction furnaces. There is very interesting discussion of hydrogen brazing.

Obsolete furnaces are not discussed. Few authors would have shown the restraint that Stansel has in ruthlessly omitting the historical and confining himself to matters of present engineering interest. The book is noteworthy for the things it doesn't waste space on and for the clarity and conciseness of what it does present. The author's long experience with the General Electric Company in the lines covered by the book has enabled him to treat his subject with authority. Beside being a highly informative volume, it is an extraordinary good job of technical writing.—H. W. GILLETT (12.1)

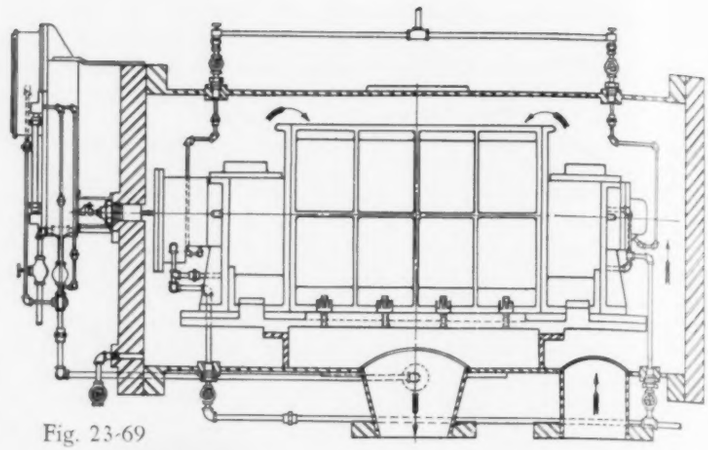

Fig. 23-69

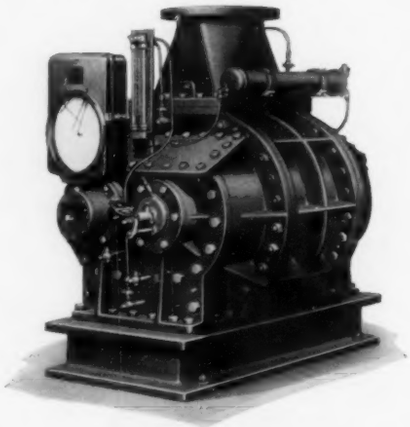

Fig. 23-70

Fig. 23-71

As a rule, pulsating or intermittent flow does not affect the accuracy of this type of meter—in the sense that the errors from such irregular flow would seldom exceed 0.5% when the average flow is well inside the accuracy range of the meter; but it is quite conceivable that highly irregular flow (downstream from a faulty regulator, for example) would cause greater errors by reason of friction and inertia effects, in spite of the use of ball bearings in the smaller sizes and of roller bearings in the larger sizes, and in spite of the lightness of the rotors and of the two sets of gears.

Fifteen sizes are made for line pressures up to 15 lb—from one with an hourly capacity of 9,000 cu. ft. (floor space 15 × 33″) to an 800,000 cu. ft. meter (86 × 146″). Fourteen meters for 50 lb normal pressure (75 lb maximum peak) range from the 8500 cu. ft. size (19 × 39″) to one rated at 467,000 cu. ft. (91 × 108″). For line pressures of 300 lb (or more), standard meters are built into steel cases, Fig. 23-69 showing a longitudinal section of one such arrangement. The temperature limits of most models are — 20° F. and 250° F.

No portable models are made. Every meter should be installed on a firm, level foundation, with the main axis horizontal; and precautions taken to avoid the least distortion of the casing. Dirty and wet gases can be metered without errors being introduced, when the flow is downward so that the meter will be self-cleaning. With clean gases, direction of flow is immaterial.

Other characteristics: Operating costs are negligible. Standard and optional accessories include differential manometers, various styles of registers, and graphic recorders (see below) for pressure, temperature, demand, etc. Meters can be used to measure and record flow in either direction, and therefore require no extra piping and valves on gas buying-and-selling installations. Tandem or compound arrangements are practicable, with a bellows meter or a smaller-capacity Connersville meter and an automatic-valve mechanism for diverting the flow.

Fig. 23-70 shows a Connersville meter, used to measure gas subject to a wide variation of pressure or temperature, equipped with the "P.V.T.T. Recording Gage" which makes a condensed record of the pressure, volume, and temperature of the gas as it passes through the meter, also of the rate of flow. The

instrument is fitted with a pressure pen, a temperature pen, and a time-recorder pen, all recording on the same chart. The chart is rotated by the meter instead of by a clock, which makes it possible to obtain the true average pressure and temperature by the use of a polar planimeter. The chart is so geared to the meter in each individual installation that when the daily volume is normal it will make approximately one revolution in 24 hours. The volumetric registration of the counter of the meter is the same as the record made on the chart. The reading of the counter is noted on each chart at the time the chart is put on and taken off. At the outer edge is a time-recorder pen which makes a mark every hour. By counting the divisions between the jogs made by this pen, the volume per hour is read off. In the center is a space for noting the time of day when the chart was put on, from which the time of day at which the maximum and minimum flows of gas occurred can be determined.

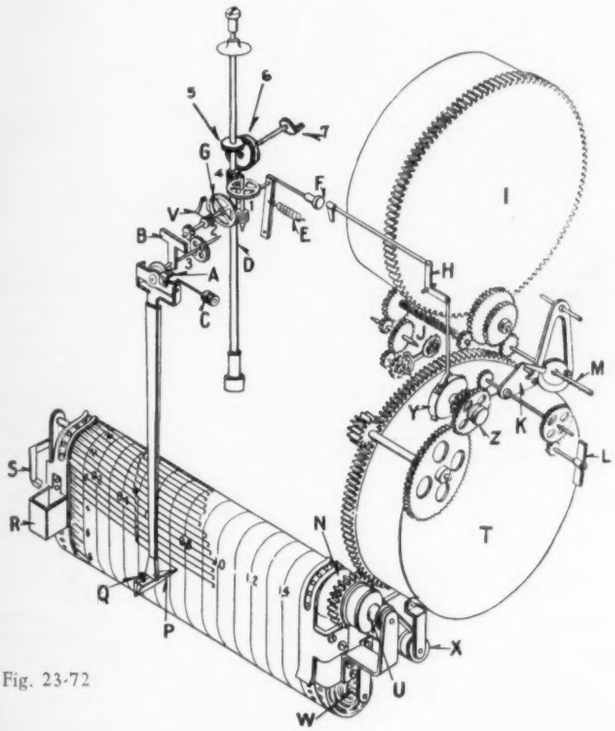

Fig. 23-72

A demand recorder is another available accessory. This instrument (Westinghouse Elec. & Mfg. Co.) records on 10" strip-charts that come in 18-foot rolls. Charts speed is ¼" per hour so that each roll is sufficient for 36 days. The gear train of the demand recorder (see Fig. 23-72) is connected to the register of the Connersville meter in such a manner that it causes the pen to travel across the chart in proportion to the cubic feet registered, At the end of definite time intervals (15, 30 or 60 minutes) the pen is released, returns to zero and immediately starts advancing again in proportion to the flow through the meter. The chart records are easy to interpret.

Remote-reading counters, etc., are also available, as well as an "Emco" pressure integrator for automatically and continuously reducing volumetric registrations to pressure-base cubic feet. This device is described below, under the Pittsburgh diaphragm meters.

"It is seldom that we find a book we can so heartily recommend . . . Must be read to be appreciated."—*Heating and Ventilating*

"Done unusually well . . . A great deal of valuable and practical data . . . of much importance." — *Maintenance Engineering*

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Vane Tags Save Time

Roy Smith, Meter Superintendent of the Manufacturers' Light & Heat Co. (Columbia System), at Washington, Pa., is responsible for the maintenance of thousands of gas meters in a large territory—among them orifice meters of various makes. Some of these were installed years ago, others recently, and Mr. Smith has made out a standardized

procedure for their inspection. One item that usually takes time does not bother his inspectors: it is finding out whether straightening vanes have or have not been installed. The explanation lies in the use of the simple brass tag herewith illustrated. These tags are 3" long and the ⅞" hole permits flange bolts to pass through.

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The Neilan Co., Ltd. (Division of Mason Regulator Co.), manufacturers of automatic regulating and control equipment, announce the opening of a new office in Philadelphia to be located at 930 North Front St. **M. N. Aitken** has been transferred from the Neilan Chicago office and will be in charge of Neilan sales in Philadelphia.

William T. Mayer, who has for several years been the Neilan Co., Ltd., representative in the San Francisco territory, has recently been transferred to the Neilan New York office, at 19 Rector St., New York City.

R. B. Werey will continue in charge of the New York office.

Don Church, who is well known in the California Oil and Gas Industries, is to be transferred from the Neilan factory in Los Angeles to the San Francisco territory.

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Case School of Applied Science

The conference on "Re-Engineering for Economical Manufacture" scheduled for March 22nd-24th at Case School was postponed to May 10th-12th because of the financial restrictions prior to the original date.

The Conference will be held with the original program and speakers beginning on the evening of Wednesday, May 10th, continuing during the morning and afternoon of Thursday and Friday, May 11th and 12th.

NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional information.

Time and Sequence Controls

The Leland Electric Co.

PRACTICALLY all problems involving opening and closing of circuits in fixed or adjustable time relation to one another can be solved, it is said, with timing and sequencing controllers announced by the above company. As large a number of circuits as may be required can be incorporated into one control. The largest one built to date has 251 circuits. Some have been built for cycles as low as 2 hours' duration; the highest speed so far is 1,000 successive makes and breaks of a circuit per minute.

The lowest rated circuit capacity is 6 amps.; the highest 100 amps. Standard d.c. ratings are 6, 12, and 20 amps.; a. c. ratings are 6, 12, 24, 50 and 100 amps. Ratings are based on 110 volt service and are reduced 20% for 220 volt service. High speed operation reduces the normal ratings, based on 15 on-and-off operations per minute. The contact-making means are Kontax mercury switches, manufactured by the above company.

A wide range of speed adjustments is obtainable. With induction disk motor, adjustment can be made by a thumb screw without interrupting the timing cycle. Timers employing 1/20 h.p. motors for drive are provided with split motor pulleys for the drive belt, which, by means of set screws, can be set close together for high speed or separated for lower speed operation. The highest speed is about 50% above the slow speed in either case.

All exposed steel parts of these controls are cadmium plated. Panel mounting is usually feasible. They are practically silent in operation.

Some standard sequence controls:

Time delay relays, direct or inverse, capacities as high as 100 amps., any desired time delay, controlled by line voltage or by low voltage.

Traffic controls, for usual or for special cycles.

Code flashers, for one fixed code or several optional codes of short and long on-and-off ("dots" and "dashes").

Motor reversers, used in laundries, etc., for periodically reversing direction of driving motors.

Motor starters, with push button for control, thermal overload protection, and delayed lock-out in case of voltage failure.

Stoker controls for periodic firing of cold stokers; to insure against failure of fire during mild weather when thermostatic control is insufficient.

Siren controls, for operating motor sirens in accordance with any desired timing cycle, with or without predetermined stop after given number of operations.

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Orifice Peep Flange

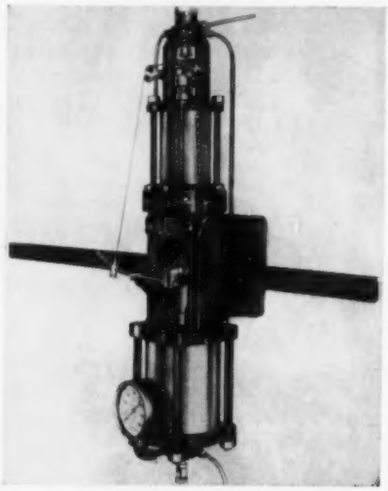
Refinery Supply Co.

VISUAL inspection of an orifice plate at any time, without disassembling or even touching its holder, has been made possible by a new flange in which 2 lenses are built-in—one lens for illuminating the orifice plate and the other for inspecting it. "R. S." orifice peep flanges are supplied for 2" to 8" gas lines, for working pressures up to 500 lbs./in.²

Boiler Regulator

Morey & Jones, Ltd.

SMALL and medium size boiler plants—where man power is limited and management is after savings—constitute the field of application of this new control device. Its function is to regulate steam pressure (up to 450 lbs./in.²) by automatically operating the damper and the firing valves. A full 12" travel of the arm end corresponds to full stroke of the piston in the 4½" power cylinder. An exclusive compensating mechanism prevents over-travel and hunting and may be adjusted to suit special conditions.



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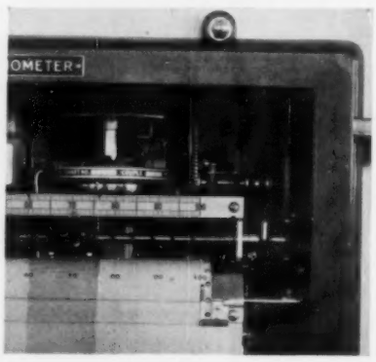
Humidity Control Resistance Thermometer

The Brown Instrument Co.

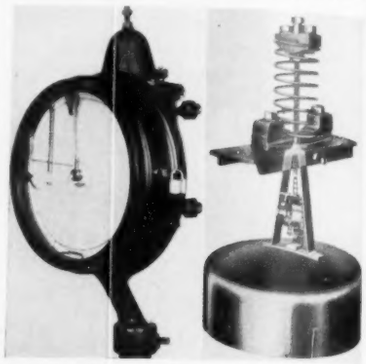
OF the wet-and-dry-bulb type with dual control, this new instrument carries 2 control indexes, one set at the temperature to which it is desired to control the dry-bulb, the other set at the temperature to which it is desired to control the wet-bulb. The first controls dry-bulb temperature by regulating valves in the heating system; the second controls the amount of moisture in the atmosphere by regulating valves in the humidifying system. The instrument operates on a balanced Wheatstone bridge principle and can be made in very narrow ranges. It is well adapted for use in air conditioning installations in schools, libraries, theatres, office buildings, etc. The photograph, showing only a portion of the instrument, brings out the form of record produced.



Bell Type Flow Meter

The Foxboro Co.

FOR measuring flow of low-pressure air or gas this new instrument has been brought out as a round-chart recorder incorporating many well-known Foxboro features but having a bell type manometer instead of a U-type manometer. This new recorder may be furnished with any of the standard primary devices—orifice plate, pilot tube, flow nozzle or venturi tube. This makes it available for use wherever low pressure loss is desirable. The instrument is built ruggedly and is not materially affected by vibration or changes in leveling. Ranges of 2.5, 5, and 10 inches of water differential may be furnished. The meter may also be used in wide range meter settings with Foxboro meters of higher ranges. In manufactured gas distribution, it is said that one of the new instruments will replace an entire battery of large positive-displacement meters. It is also recommended by the makers for low-pressure compressor discharge, gas-gathering systems, gasoline plants, glass plants, ventilating ducts, etc. The measuring element (see right-hand figure) employs the spring-loading principle, the heat-treated chrome-vanadium spring being worked so far below its proportional limit as to be fatigue-proof. Straight-line motion is obtained by the segmental-lever principle employed in other Foxboro flow meters.



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Stationary Tachometers

Jones-Motrola Sales Co.

TWO models of tachometers are announced by the above company. One is a "stationary" device with the 5" pulley and the 8" dial instrument arranged on both sides of a pedestal bearing; the other is a 6" dial, flexible-shaft drive instrument arranged for mounting on a panel board.

Both tachometers are of the ball-governor centrifugal type, but they differ from most tachometers of this type in that their scales are uniform.

The *Jones Stationary Tachometer* is made with horizontal shaft and vertical pulley or vice versa. Its pedestal has an 8¾" base. Each instrument is calibrated individually. The 8" dial has full-circle graduations, the lower 20% of the scale being suppressed.

The *Jones Type M6 Tachometer* is 6½" in outside diameter and 4" deep overall with a dial case 1⅛" deep—practically "flush." It, too, is calibrated individually and has full-circle graduations from 20% to 100% of its speed range.

The Brown Area Flow Meter

By Louis Gess*

To measure the flow of heavy oils, chemicals, food-stuffs, etc., has been difficult in the past due to the complex arrangement of piping and seals required between the meter body and pressure taps when using standard differential and orifice-type flow meters. Heavy oils must be heated in order to flow freely and the transmission of pressure entails difficulties due to the cooling of the fluid in the lines connecting the pressure chambers with the pressure-measuring device. When metering chemicals the usual difficulty is that the fluid must be kept out of contact with the mercury or oil in the usual meter-body. This requires special seals, sealing mediums and complex piping arrangements. Installations require constant attention to avoid corrosion due to small leaks in the connecting tubing, to prevent the chemical from penetrating the sealing medium and attacking the working parts of the meter-body and to make sure the chemical fluid does not become contaminated by having some of the sealing medium spill into the flow pipe which is caused very easily by surges in the flow. When metering food-stuffs the fluid being measured must not be contaminated in any way.

The area-type meter meets all these requirements. Seals and auxiliary piping between the meter body and pressure taps are not required by the newly-developed Brown Area-Type Flow Meter because the meter body is installed directly in the pipe line—see photograph. Many other applications for the Brown Area-Type Flow Meter have been brought to light since its introduction.

Principle of Operation. The meter-body is of the piston and sleeve type. As the fluid enters the meter body it strikes the bottom of the piston. Since the piston is free to slide vertically upward, it will be lifted, exposing a section of the rectangular orifice in the sleeve. As the fluid escapes through this orifice, it rises through pulsation throttling orifice into the space above the piston and exerts a downward force on the piston equal to the area of the piston times the pressure of the fluid of the downstream side of the orifice. The piston comes to rest when the forces are in equilibrium, which occurs when the orifice is opened sufficiently to make the downstream pressure equal to the pressure P_1 in the following equation:

$$PA \quad P_1A + W, \text{ or } P\text{–}P_1 = \frac{W}{A}$$

where P = the upstream pressure
P_1 = the downstream pressure
A = the area of the piston
W = the weight of the piston and armature

The difference between P and P_1 is a constant, depending upon the weight of the plunger divided by the area of the piston. The meter, therefore, operates to maintain a fixed pressure drop across a variable orifice.

The position of the piston is measured by the inductance bridge method: as the armature travels vertically in the non-magnetic tube, surrounded by a divided inductance coil, another armature in the receiver assumes corresponding positions which are a measure of the area of orifice opening in the meter body, and hence of the rate of flow. The Brown Area-type Meter is calibrated to give equal increments in deflection for equal increments in flow, hence the scales and charts are evenly graduated. Since this is accomplished without the use of cams or specially shaped pressure chambers, the forces which shift the piston position are as great at small flows as at large flows, so that the meter is as accurate at low flows as at large flows.

Constructional Features. A complete equipment consists of the following: (1) Meter Body, (2) Recording or Indicating Meter and (3) Connecting Wiring. The meter-body is a complete unit in itself, no valves, seals, nipples, tubing, mercury or separate orifices being required. Installation cost is low as the amount of work is about the same as that required to install a 2″ valve. The range is adjusted by adding weights to the piston cup and by installing a different orifice sleeve. Large piston area (5 in.²) enables the meter to operate with a low total pressure drop in the line and yet respond to any changes in the flow conditions. Depending upon the application, the meter-body is furnished with either a steam jacket or radiation jacket mounted just below the inductance coil.

For measuring water (or fluids having approximately the same specific gravity) the ranges vary from 0-150 g.p.h. minimum to 0-2000 g.p.h. maximum. The meter capacity is less for fluids having a specific gravity less than that of water. The actual capacity is determined from the ratio of the square root of the density of the fluid measured to the square root of the density of water at the same temperature. For example, for a fluid whose density is one-half that of water, the maximum capacity of the meter is only 70% of that when water is measured. It is furnished in one pipe size only, 2″. Where pipe line is smaller or larger than 2″, the user inserts a section of 2″ pipe for a distance of 15 pipe diameters on each side of the point in the line where the meter body is to be installed.

The receiving meter, which can be located at a remote point from the meter-body, can be had in the following types: (1) Circular Chart Recorder, (2) Circular Chart Recorder with Indicating scale, or (3) Circular Dial Indicator. The inductance-bridge principle makes it possible to operate two receiving instruments off one meter-body. This means a circular chart recorder and a circular dial indicator can be operated in parallel off one meter-body. This feature is often taken advantage of by installing the indicator near the operator's post and recorder in the engineer's office.

*Flow Meter Engineer, The Brown Instrument Co.

Fig. 1

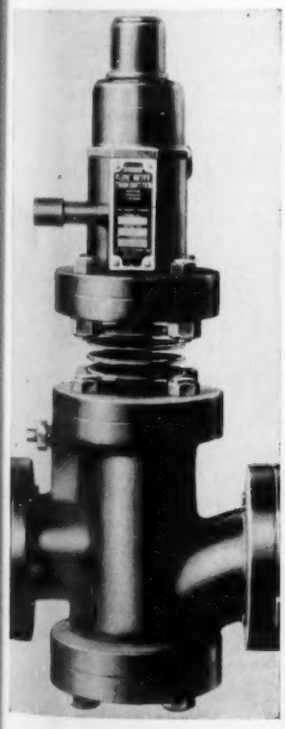
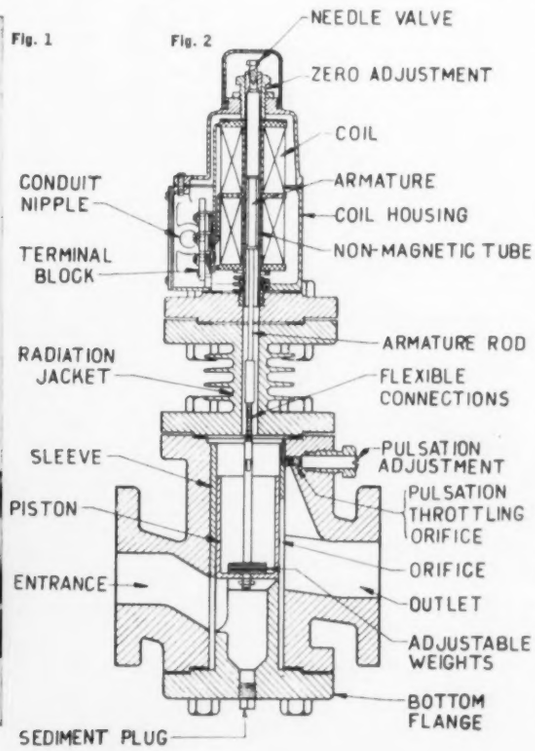


Fig. 2



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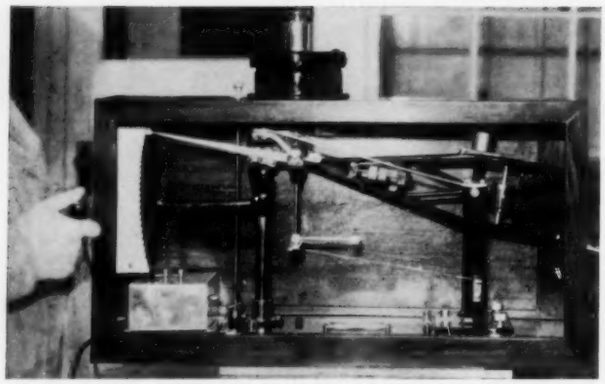
New Line of Moving-coil Meters

The Triplett Electrical Instrument Co.

THE new Triplett line of D'Arsonval moving coil instruments, consists of 2 sizes in 3 case models. Furnished in low reading micro-ammeters, milli-ammeters, voltmeters up to 2,000 volts, milli-voltmeters, and ammeters. No. 321 (3½″ case with 2⅝″ scale) is furnished with screws for rim flush mounting. The same size, Model 325, is also available for front of board mounting. No. 223 (2″ case with 1¾″ scale) comes with a narrow rim and clamp for flush mounting. The new instruments fit around a molded Bakelite plate in which the terminals and assembly studs are firmly anchored. The metal dials are white enameled with black lithographing. Fine sapphire jewel bearings are used. The aluminum needle and other parts are ribbed and made unusually strong. The moving coil is light in weight. The scales are uniform and easy to read. Sealed cases are of one-piece construction.



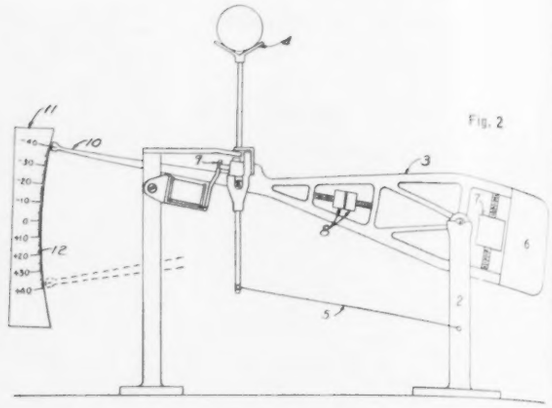


Fig. 2

Toledo Dynamic Weigher

Toledo Precision Devices, Inc.

IN virtue of a new principle of weighing, this new scale determines the mass of an article or commodity by measuring inertia while it is in motion, hence the name Dynamic Weigher. Speed and accuracy are combined to a high degree: speed because it is unnecessary to wait for the scale indicator to settle to rest; accuracy by the extreme sensitivity of the device so that masses of several pounds can be measured to an accuracy of one grain. A third advantage is automatic indication.

Principle of Operation—If a free, swinging pendulum be pulled out of vertical position, then released, it will swing to a point the distance of which beyond the vertical is dependent upon the distance the pendulum was pulled out of vertical position before being released. Placing a weight upon one side of the pendulum moves the center of mass of the pendulum toward that side. The greater the weight placed upon one side of the pendulum, the farther its center of mass is moved. Hence, if while the pendulum is held against movement, weight is placed upon it at one side of its vertical, the pendulum when released will swing through an arc, the length of which is dependent upon the amount of added weight. The Toledo Dynamic Weigher is, in fact, a pendulum. When this pendulum is released under load, it swings the indicator downward along a chart and the reading is made at the point on the chart at the farthest point of the swing.

A fulcrum stand 2 (Fig. 2) supports, by knife edged pivots, a lever 3, capable of swinging from the position in which it is shown to the position shown in dotted lines. Pivotally carried adjacent to one end of lever 3 is a scoop 4 adapted to receive articles to be weighed. The upright position of the scoop is maintained by means of link 5 which in this form of the device, is made of tungsten wire. To simplify description, assume that a piston is to be weighed. Scoop 4 and the piston are substantially counterbalanced by counterweight 6. The center of mass of the lever and the parts carried thereby, can be adjusted vertically by moving weight 7 and longitudinally of the lever by moving weight 8.

The scoop end of lever 3 is held in the upper position by means of catch 9 releasable by an electric magnet. With the piston on the scoop, catch 9 is released. The lever then swings through an arc, the length of which depends upon the weight of the article being weighed. The extent of the swing is indicated by means of hand 10 and stationary chart 11 with graduations and figures 12 to indicate the weight of the article being weighed. In the model described (1 kg. capacity), the graduations on the chart each represent 0.01 g. (To meet the requirements of special weighing operations, the charts are divided into classification zones and marked to give the desired information.)

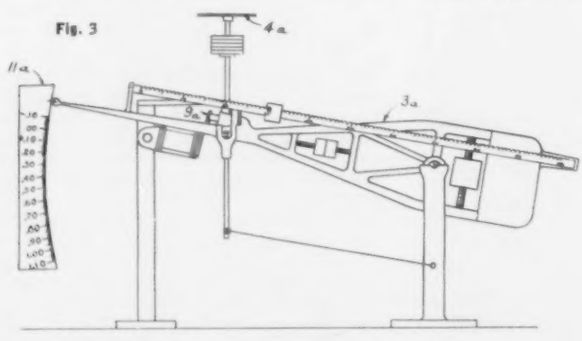
When the hand swings down to the farthest point, without pausing, it rises and returns to approximately its original position, being held there by the catch. It is only necessary for the operator to read the lowermost point reached by the hand to know whether the piston is underweight or overweight and by how much. The weight of the piston can then be trimmed by machining off (if overweight is shown), or adding the amount of the underweight (if underweight is shown). The precision attained in this operation is comparable to that attainable by the use of a laboratory balance, but results are secured in much shorter time.

For laboratory weighing, the Toledo Dynamic Weigher has been devised in the form illustrated in Fig. 3. In this form, the commodity receiver 4a is provided with a series of five removable 100 g. weights, while lever 3a is provided with a beam, having a capacity of 100 g., graduated by 1 g., and chart 11a has a capacity of 1 g. graduated by 0.01 g. In laboratory tests for moisture absorption, evaporation and similar other variables within the capacity of the chart the device gives accurate results with great speed. After adjusting it for the approximate weight by removing some of the loose weights and setting the poise, the commodity is placed on receiver 4a. Catch 9a is released and the exact weight of the specimen being tested will be instantly indicated upon the chart 11a. The 0.01 g. graduations on the chart are spaced at intervals of 3/32 (.093) in.

In using this model for laboratory weighing of loads beyond the chart capacity of 1 g., the specimen is first roughly weighed on the Laboratory Computagram, 500 g. capacity, or on another such scale to determine the weight of the article in units of grams. For example, assume that the Laboratory Computagram indicates the weight of the article to be slightly more than 241 g., but not 242 g. The specimen is then brought to the Toledo Dynamic Weigher. Two of the 100 g. weights are removed from under the commodity receiver 4a. The specimen is then placed in the commodity receiver, the 200 g. in its weight replacing the weight of the two 100-g. weights which are removed. The poise is then set on the beam at 41 g., thus accounting for the total of 241 g. The catch is released and the indicator hand swings down on the chart to a point which indicates the number of hundredths of grams which the specimen weighs over the 241 g. If the indicator reaches .83 on the chart, the weight thus determined would be 241.83 g.

Automatic Classification with Photocell—In Fig. 4 is illustrated the form of the Toledo Dynamic Weigher equipped with an electric eye classifier. The chart 11b in this form of the device is provided with a slot upon one side of which is located a lamp 13b from which light

Fig. 3



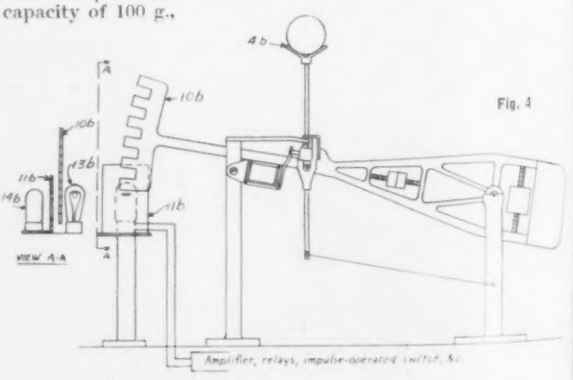


Fig. 4

passes through the slot in the chart to photo tube 14b. The indicating hand 10b is provided with a series of extensions which, as the hand swings down, successively interrupt the passage of light through the slot. The photo tube is connected through the amplifier to an impulse-operated switch which may control as many circuits as there are desired classifications. As each tooth of the extension on hand 10b interrupts the passage of light to the photo tube, an impulse is transmitted to switch. The circuits controlled by the switch may be employed to divert articles or packages tested into bins or onto conveyors, according to their under- or over-weights; or they may be employed to control indicators or signals to operators of trimming machines, or even to set trimming machines themselves.

In the description above, the weighing of a piston has been used as an illustration. Bearings, valves, cams and other reciprocating and rotary parts can be classified on a production basis to a laboratory degree of accuracy. Wholesale drug manufacturers may rapidly check-weigh batches of ingredients. High priced commodities such as teas and spices, may also be accurately weighed at high speed. Cartons containing a group of similar articles may be check-weighed to discover accidental omission of one part.

No more severe requirement can be placed on a weighing device than the accurate weighing of test weights. The Toledo Dynamic Weigher has speeded up scaling time, changing what was formerly a fiddling, fussy operation into a rapid manufacturing process.

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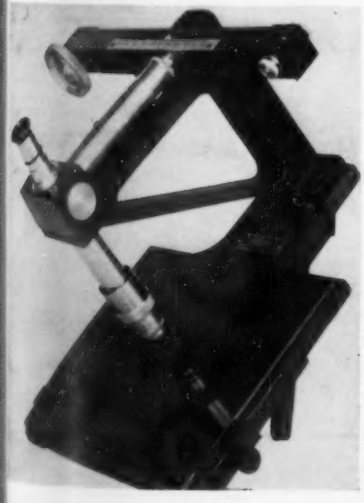
L496 Microdensitometer

Gaertner Scientific Corporation

THIS instrument is especially designed for measuring the densities of spectrum lines on photographic plates, and consequently for making quantitative photometric determinations of the intensities of spectrum lines in the visible, ultra-violet and X-ray regions.

The density of the plate to be measured is compared photometrically with the known density of a neutral absorbing wedge which provides varying amounts of illumination to one part of the photometric field as different integrals of the wedge are used. The motion of the wedge is controlled by a large knurled head, which may be operated by the left hand, keeping the right hand free for making notations. A 50 watt frosted lamp furnishes the source of light which is split into 2 beams, one passing through the photographic plate, and the other through the optical wedge. The wedge and plate are thus illuminated symmetrically and the 2 resultant beams are compared by means of a photometer cube. A provision is made for compensating for the grain of the photographic plate by the insertion of a grain plate in front of the wedge. The spectrum lines are clearly visible in the field while measurements are made.



The photometric field is produced in a photometer cube at the focal plane of the eyepiece. A strip 2 mm. wide is silvered on an interior diagonal face of the cube, with the exception of a small central portion 0.1 mm. in width which divides the strip into 2 equal longitudinal parts. This silvered strip reflects the light transmitted through the absorbing wedge into the field of view and appears in a horizontal position perpendicular to the spectrum lines. The light passing through the spectrum plate produces an image of the lines which also appears coincident with the strip at the focal plane of the eyepiece. The spectrum line to be measured is selected and brought into position midway between the 2 portions of the strip producing a continuous field. The wedge is then manipulated so as to match both sides of the strip with the spectrum line, resulting in a continuous strip of uniform intensity. The extremities of the spectrum line are in full view against a light field all during the matching process. This permits the operator to look for a variance of density at different parts of the line and comparative density determinations can then be made. An uneven slit width or dust on the slit of the spectrograph will cause uneven densities to occur in the spectrum lines.

The neutral absorbing wedge is 100 mm. long and its position is indicated by a millimeter scale and index. The variable densities of this wedge are proportional to its displacement on the scale, the range being from 0.4 to 4. These figures represent the logarithms of the reciprocals of the transmission coefficients of the wedge, thus the range of transmitted light is from 1 to .0001.

Motion of the wedge is effected by a flexible steel band providing simple and smooth operation and eliminating any possibility of back-lash. Provision is made for mounting a grain plate directly in front of the wedge so that one of the microscopes can be focused upon this plate. A similar plate mounted below the spectrum plate will compensate the difference in light intensity, so that exact matching of the photometric field is possible without defocusing.

The microscopes transmitting the 2 paths of light to the photometer cube are optically similar, and are fitted with 36 mm. E.F. objectives. The field is viewed through an eyepiece of 25 mm. E.F.L. at a magnification of about 15 diameters. About 5 mm. of the spectrum plate may thus be seen at one time. Two adjustable draw tubes at the ends of the microscopes, when placed flush against the plate and wedge, serve to exclude extraneous light and permit the use of the instrument in a lighted room.

Simplified Model Micro-Metallograph

E. Leitz, Inc.

THIS new apparatus represents a modified and simplified construction of the makers' Large Model MM-1. It includes all essential optical and mechanical equipment to meet all practical requirements from carbon-iron alloys to metals of all different kinds. It employs the same type of inverted microscope stand that is furnished with the large Micro-Metallograph MM-1. In place of the arc lamp is substituted a low voltage lamp of extreme light intensity. The principal characteristics are summarized as follows:

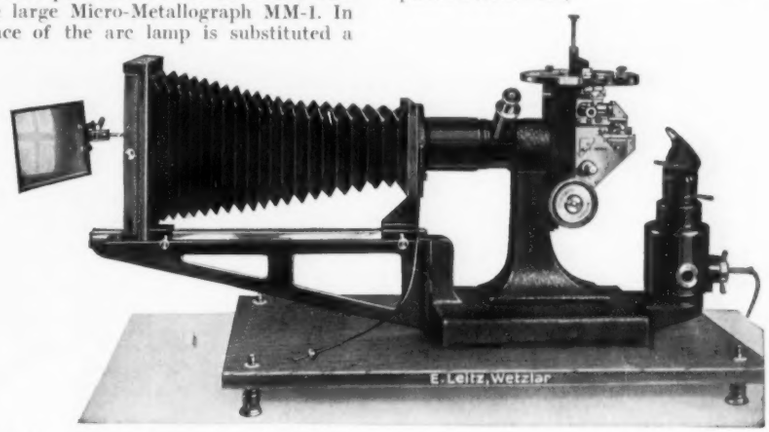
(1) Micro magnifications from 25X upwards;

(2) Magnifications of general features without eyepiece from 10X upwards;

(3) Inverted microscope stand equipped with large built-in mechanical stage with scales and verniers imposing no restriction in respect to the size and weight of specimens;

(4) Quick transition from the customary brightfield mode of illumination to the new mode of *darkfield illumination*, without change of objective;

(5) Camera plate 5x7 in. with kits for plates 3¼x4¼ in.;



(6) Camera detachable and available for taking macroscopic photographs with standard photo lenses on separate stand;

(7) Filament lamp illumination: economical and may be connected to any supply current;

(8) All bright parts chromium-plated, therefore, thorough protection against laboratory fumes.

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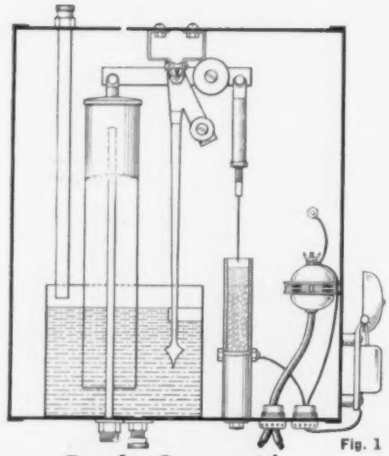

Fig. 1

Draft Gage Alarm

Ellison Draft Gage Co.

A SENSITIVE and durable electric alarm system can now be furnished in either the Ellison straight-line or the dial type pointer draft gages for minus, plus or differential readings, and for either high or low draft alarm. Transformer can be furnished for either 220 or 110 volts, dry cells being used for other than a.c. current. The system consists of a transformer, a bell, and a mercury chamber and contact rod comprising the switch. The mercury is covered with oil for sealing against arcing and oxidation. The contact rod is suspended on the beam of the gage, on a knife edge bearing, and is adjustable so as to ring the bell at any point of the scale, within a variation not to exceed 0.01". Fig. 1 shows the dial type gage equipped with alarm for low minus draft. Fig. 2 shows the gage with 1" scale range.

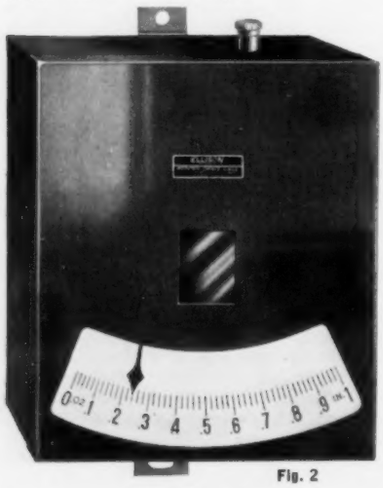

Fig. 2

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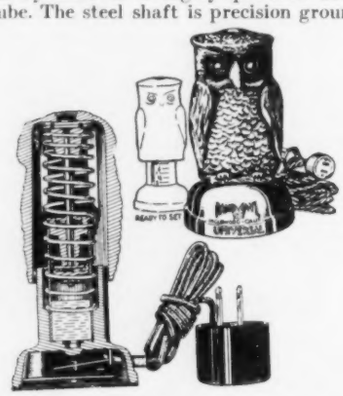
"Radio Owl" Timer

Universal Microphone Co., Ltd.

AUTOMATIC disconnection of receiving sets or other electric household appliances is effected after any desired period of time, from a few minutes to 2 hrs., by this novel timer. The "Radio Owl" is installed by simply plugging in. It operates as follows: When the body is pushed downward, oil at the bottom of a cylinder is forced past a piston. An internal spring then exerts an upward force on the body, but this action is retarded by the slow leakage of oil through the piston valve. All working parts are immersed in oil, eliminating wear by friction or rust.

The body and base are of metal. The oil cylinder is a highly polished brass tube. The steel shaft is precision ground.



The switch block, of hard rubber, completely insulates the electrode from the base, preventing possibility of short circuits. There are no springs to wind. The "Owl" is 4½" high by 2½" in diameter, finished in bronze and has red jeweled eyes.

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Wire and Tube Flaw Locator

General Electric Co.

FLAWS and cracks in rare-metal wire, copper tubing, etc., are detected by a new vacuum tube oscillator which has already shown its value in the manufacture of General Electric products where the visual detection of small defects is a very slow process, requiring extreme care, and is often entirely inadequate. Although originally designed to locate longitudinal cracks in tungsten or molybdenum wire, the device is being successfully used to find flaws in copper tubing. In both cases, flaws are detected by means of eddy currents induced in the material inspected. In the tubing test, eddy currents are induced in a small portion of the tubing by passing it through a coil connected in an oscillator circuit. 2 oscillators are coupled together and connected through an amplifier to a loudspeaker and an instrument. Each of the oscillators is provided with a coil. Either or both of these may be used as test coils through which to pass the tubing. With a good section of tubing in the test coils, the oscillators are both tuned to the same frequency. Then, as the tubing is passed through the coils, a flaw will change the induced current sufficiently to change the frequency of one of the oscillators and cause a beat note in the loudspeaker and a deflection of the instrument. The device described detects local flaws and sudden changes in characteristics of the material. By using 1 test coil instead of 2 it may be used to detect gradual changes in characteristics or to compare the material with a standard. The device may be used also to operate a relay.

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Moving Iron Vane Synchroscope

Westinghouse Electric & Mfg. Co.

COMPLETING their new type H line of square switchboard instruments, the above company announces a new synchroscope characterized by low energy consumption, the burden of each circuit being about 4 voltamperes, making the instrument especially desirable for use with condenser bushing potential devices. Position indicators and 360° scale power factor meters are also available in this form of instrument.

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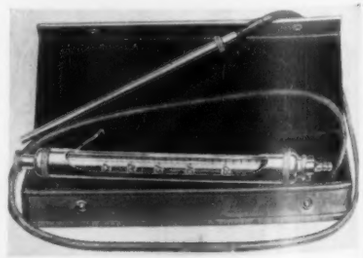
Smoke Tube Draft Gage

E. Vernon Hill Co.

IN THIS new instrument the pressure difference does not cause a difference between 2 liquid levels, but it causes a downward flow of air through a fixed orifice and into the smoke chamber, clearing the smoke from the upper portion as far down as the jet is effective. The length of the jet increases with the pressure difference, making it possible to calibrate the instrument by comparison with a master gage. Directions for use:

1. The instrument is held by the left hand by the ring. The static tip is held in the right hand. Remove plug from bottom and fill the tube with dense smoke from your cigar or cigarette.
2. Replace plug and close intake nozzle with thumb or finger. Insert a static tip wherever a reading is to be taken.
3. Remove finger from the intake nozzle. Air rushes into tube and clears smoke down to a point on the scale which gives the static pressure in inches of water. This is the draft reading.

It makes no difference whether the smoke is thick or thin, whether it is from a cigar, cigarette, or pipe. The smoke simply acts as a medium for visualizing the air jet. It makes the behavior of the air visible, and the character of the smoke has no effect on the accuracy of the instrument.



Universal Yarn Numbering Balance and Ruler

Alfred Suter

DETERMINING the yarn numbers of any kinds of yarns, from short lengths weighing but a few milligrams, has been transformed from a slow, fussy and inexact procedure into a rapid and accurate operation, by a new precision balance used in conjunction with a new linear measuring and cutting ruler. The balance (Fig. 1) is

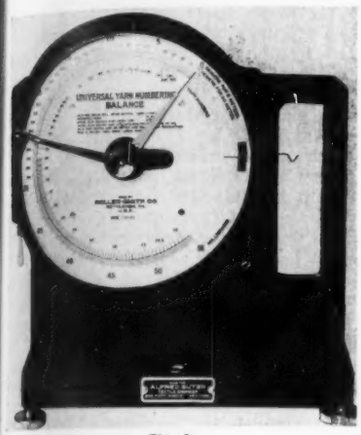


Fig. 1

designed for operation from outside, there being only one delicate part accessible and this part—the hook on which specimens are hung—being located in a glass-enclosed measuring chamber which is opened only when a measurement is to be made. The special ruler (Fig. 2) has appropriate graduations for cotton, spun silk, rayon, worsted, linen, etc., and a convenient cutting tool.

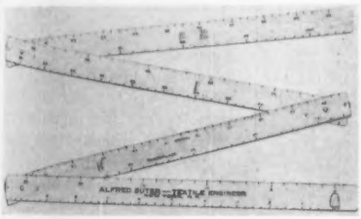


Fig. 2

The balance can be used also for general weighing purposes, as it is additionally graduated 0-55 mg. and can be read to 0.1 mg.

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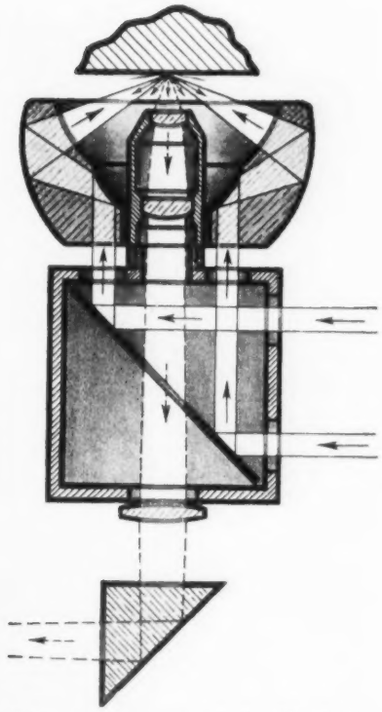
Darkfield Illuminator

E. Leitz, Inc.

MAGNIFYING power, in itself, plays a smaller part in revealing fine structure than is generally known. Illumination intensity, too, often fails to produce hoped-for results. The method of illumination, it is now realized, is all-important. In recent years various illuminators have appeared—none free from serious drawback. There is now announced a novel device and a new series of objectives for use with the makers' micro-metallographs "MM-1" and "MM-2." The method involved consists of inserting an opaque stop or bull's eye into the tube of rays at a definite



distance from one of the illuminator lenses, so that an image of this stop is formed in the plane tangent to the rear lens of the objective. This method does not form a dark spot in the center of the reflected image. The effect is that the center portions of the objectives are available for the numerical aperture of the observation system but not for the aperture of the illumination system. With this darkfield conical illumination device, excellent resolving power is combined with remarkable contrast. Furthermore, the darkfield illuminator can actually reveal ultra-microscopic constituents. Extremely interesting results, it is said, are reported almost every day.

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General Purpose Meters

Chauvin Arnoux et Cie

SMALL enough to be slipped in a vest pocket (5″x3″x1″), and weighing only 14 oz., the Contrôleur Universel can be used for so many different measurements that its makers call it also

"The Pocket Laboratory." Eleven different ranges permit voltage measurements from 0.2 to 750 volts; current measurements from 40 microamps. to 7.5 amps. and over by the use of shunts, for both a.c. and d.c. There are no terminals, connections being made with plugs. An instruction booklet shows with the aid of diagrams where to plug in, what scale to use, etc. for various measurements, including self-induction, capacity, resistance, etc.

Industrial model. Exactly similar in appearance and technical characteristics, but the 11 ranges are: 0.12, 0.6, 1.2, 6 and 12 amps.; 6, 24, 60, 120, 240 and 600 volts, both a.c. and d.c. For a.c. current above 12 amps. a small transformer affords the ratios 30:1.2, 60:1.2, 120:1.2, 300:6, 600:6 and 1200:12. The weight and dimensions of this transformer are the same as those of the instrument. The instrument, transformer and connections fit into a deerskin-lined pigskin carrying case 8″x5½″x1½″.

A series of external shunts is available. These fit into the carrying case in place of the transformer.

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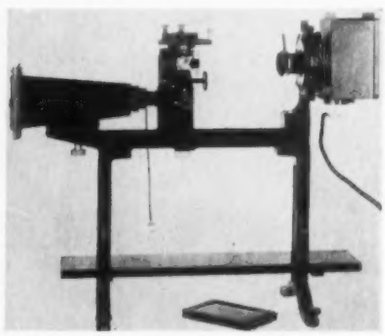
Routine Metallographic Microscope

Bausch & Lomb Optical Co.

THIS medium priced instrument was designed to meet the demand constantly manifested by industrial laboratories and schools, for an equipment capable of producing with speed and facility the finest routine photomicrographs at standard magnifications. The equipment consists of a cast iron stand on which is mounted the inverted microscope, camera and illuminant. The inverted microscope is the center unit permanently mounted on the cast iron frame. At the right of it is the illuminator and at the left the camera. A polished metal specimen, when inverted and laid on the stage, is quickly focused by means of a coarse and fine adjustment. A convenient prism in the optical path diverts the optical beam from the observer's eye to the camera plate for making photographs.

Since the general routine work barely exceeds 500 times magnification, the optics with this equipment, which includes 4mm, 8mm, 16mm and 32 mm objectives, 5x, 10x and 12.5x eyepieces, give magnifications of 25, 50, 100, 200 and 500 times. These are standard magnifications specified by the A.S.T.M.

The camera is supplied with a shutter for bulb or time exposures. A ground glass focusing screen and a double plate holder for a 3¼″ x 4¼″ plate. Cut film holders are available if desired.



Recorder-Controller for Materials Testing Machines

Baldwin-Southwark Corp.

IN reality, this instrument is the combination of several devices, distinct from one another and associated for the purpose for the first time. Functionally, it provides in this combination—and in alternative combinations—(1) an autographic stress-strain recorder which produces a graph up to incipient failure, or which may, by adaptation, produce a graph to and through failure on metal, wood or any other material; (2) an instrument which is all of (1) and in addition controls load application to effect constant rate of strain increment, constant rate of load increase and load maintenance at constant value. The instrument in no way limits manual control; such control is inherent up to any predetermined point at which the instrument takes over the control function and proceeds to exercise it to a point elected by the operator.

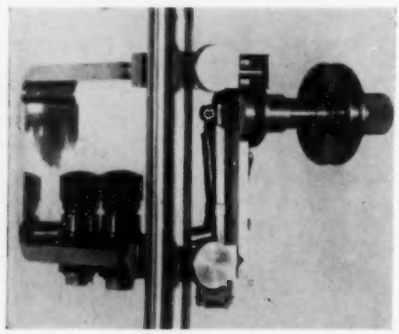


Fig. 1

Basically these devices are combinations of (1) extensometers, (2) Bourdon tube, and (3) hydraulic valve in association with motors, relays, solenoids and mechanical clutches.

The extensometer—or more properly, strain gage—is fundamentally a micrometer screw in combination with a mechanical lever multiplying system. (See Fig. 1.) It is easily attached to the specimens, the gage length being fixed by the extensomoter itself. After tightening 2 thumb screws, the frame is released by a small cam lever and the extensometer is free to operate. It is not primarily an indicating instrument, but a relay—a link between the varying gage length and the recording pencil. As the specimen extends (or contracts) an electrical circuit carrying a very minute current is broken, the motion of the contacts being multiplied by the lever system. The recorder, using a source of power outside the extensometer, proceeds at once to re-establish the circuit by turning the micrometer screw until a new contact is made. Action at once ceases. But this effort of the recorder to re-establish a broken circuit serves as the means of moving the recorder pencil by the proper amount to record the strain variation. This motion is linear and the values along the ordinate on the graph are strain values. The sensitivity is such that 0.00002 in. strain may be made to produce a perceptible motion of the recording pencil, while its accuracy is $\pm$ 0.00005 in.

A precision Bourdon tube pressure-measuring element is incorporated in the Southwark-Emery Stress-Strain Recorder-Controller (Figs. 2, 3 and 4) as the control element for the motion of the recorder drum which supplies the other co-ordinate necessary to the stress-strain graph. The guaranteed accuracy of these gages is 0.75% of load from 10% to 100% capacity. Actual performance is usually better than the guarantee and accuracy is unaffected by lapse of time.

The Bourdon tube operates a light metallic arm on the end of which is a coiled nickel wire having a short projecting straight portion—a "cat whisker" of the early days of radio. Facing this arm is a disk mounted on a shaft whose axis is coincident with that of the arm. On the disk face is a coin silver strip whose radius is that of the "cat whisker." This strip is interrupted for a very short distance at 2 points. As the arm rotates under the urge of the straightening Bourdon tube, an electrical circuit is closed between the "cat whisker" and one of the 2 smaller segments of coin silver. In this circuit is a sensitive relay which, in turn, controls current through an electro-magnet which, when energized, causes a sensitive fine-tooth clutch to engage. Power from a continuously running motor serves to move the disk forward and to break the minute current of the control circuit. The clutch immediately disengages and since the worm-and-wheel drive is self-locking, there is no over-run. Attached to the mechanism actuating the disk is the drive which rotates the recording drum (which carries the graph paper) in strict proportion to the movement of the arm, which movement, in turn, is in strict proportion to the load on the specimen under test. Thus the Bourdon tube has no more work to perform than it would have if it were indicating only.

The currents through the contacts—shunted by a condenser and a resistance in series—are so weak that arcing is negligible. Yet, through the mechanical and electrical interlinks, power of the order of 1/20 h.p. is controlled, to do the work of recording. The same motor, through a duplicate toothed clutch whose action is controlled by current through the contacts (previously described) in the extensometer, provides power for the movement of the recording pencil, which also moves in strict proportion to the variation in strain. Through the multiplication by levers in and by the micrometer screw of the extensometer and by the radius of the pulley on the micrometer screw (Fig. 1), ratios of as much as 2000 may be had. It is found, however, that a multiplication ratio of 250 to 750 provides greater all-around satisfaction for most laboratories except, possibly, those devoted to research.

All parts described in the foregoing are essentially those of the recorder alone. They also are integral parts of the recorder-controller. This instrument not only makes a record but also controls the *time-rate* of application of stress or strain at the command of the operator.

For the achievement of constant rate of strain variation, it is necessary only to provide a moving contact (Fig. 4) along the path of the pencil travel; i. e., along an ordinate of the stress-strain graph. The velocity of this moving contact is controlled by a small synchronous motor and a group of readily changed gears (Fig. 3). 12 speeds are available: 6 on an inches-per-minute basis and 6

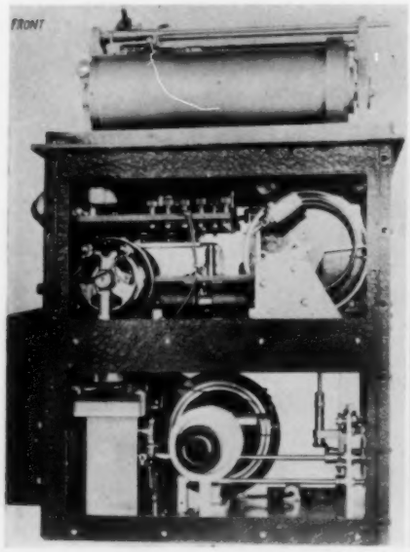


Fig. 2

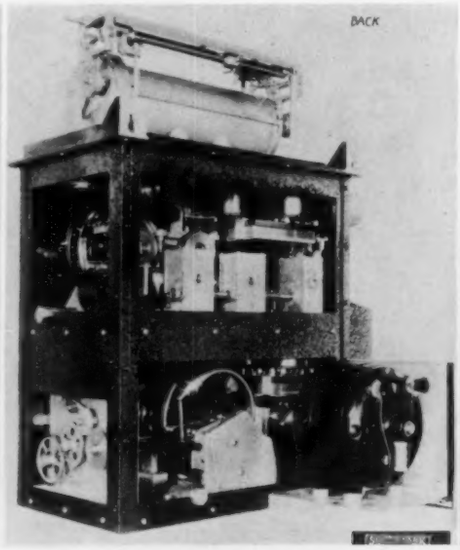


Fig. 3

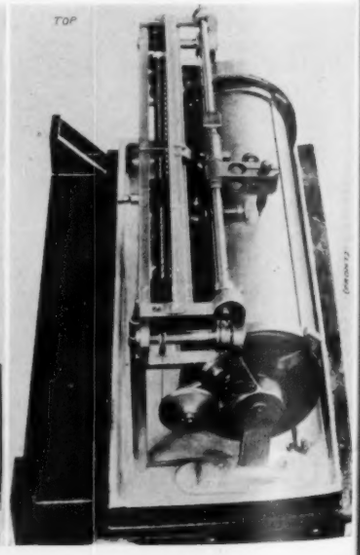


Fig. 4

on an inches-per-hour basis. (In other terms, speeds from 0.0001 in. per inch gage length per hour to 0.002 in. per inch gage length per minute.) The number of steps may be indefinitely extended by the multiplication of sets of change gears. Provision is made for all testing speeds up to the maxima recommended by the A.S.T.M. (For speeds higher than these, special provision against lag of recording pencil becomes necessary.) The synchronous-motor-controlled moving contact commands a power-operated hydraulic valve which admits more or less fluid to the load-producing cylinder of the testing machine. The *strain* in the specimen (which means movement of the ram in the load-producing cylinder) is thus controlled as to time-rate by the quantity of fluid admitted to the cylinder from the pressure supply.

In like manner, an auxiliary disk of the same type as that described for the recorder is driven by a synchronous motor (Fig. 3) at various desired velocities. Contacts of the same type as those previously described serve to control, through the valve, the quantity of fluid admitted to the cylinder and, therefore, the time-rate of *stress* application. Speeds of stress application to one-half the capacity of the testing machine per minute are available.

In both rate-of-strain and rate-of-stress control, slippage of the specimen in the grips, of the grips in the heads of the testing machines, and strain outside the gage length of the specimen, have no effect on the controlled rate of strain or stress application. The only possible case of failure of the control would be a slippage so rapid that the flow of fluid from the pump would not be sufficient to cause the load-producing ram of the testing machine to follow up with the requisite velocity.

In the application of a constant load over a period, a disk with an interrupted metallic strip and a "cat whisker" is made to control the valve and to admit only enough fluid to the cylinder for creep (if any) and for leakage in the hydraulic load-producing system. The length of time available for load maintenance is limited only by the capacity of the hydraulic pump supplying fluid under pressure to the load-producing cylinder of the testing machine.

It is possible, also, to produce strain-time or stress-time graphs by availing of the synchronous motor motions described in connection with the constant rate of strain and constant rate of stress devices.

The development of this recorder-controller for application to those types of testing machines having mechanical load-producing mechanisms and lever type weighing systems has not yet been made. The application of the recorder alone is easy: the motion of the poise is made to move the pencil along the ordinate while the extensometer is utilized to control the rotation of the drum in the same manner, fundamentally, as previously described.

Altogether, the devices represent a step forward in the field of materials testing. It has never before been possible to control automatically and within narrow limits, rates of strain and stress application. With some non-ferrous materials, these rates are of vital importance in the interpretation of test results.

Flow or Level Indicator

Morey & Jones, Ltd.

FILLING the need for a moderately priced direct-reading differential pressure gage of the metal bellows type, this new instrument indicates flow rate when connected to a differential producer, or liquid level when connected to a tank. The readable dial may be furnished calibrated in inches of differential, in g.p.m. of flow, etc. The shaft transmitting bellows motion to pointer mechanism is of small diameter and runs through a packing gland, to keep liquid out of dial case. Suitable stops prevent injury to pointer if instrument is subjected to an excessive differential. An outside zeroing adjustment is provided. The indicator is built for 250 lbs./in.^{2} maximum working pressure; and for differentials ranging from 5 in. Hg to 25 lbs./in.^{2} Accuracy is within 1.5%.

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Hand-less Electric Clock

General Electric Co.

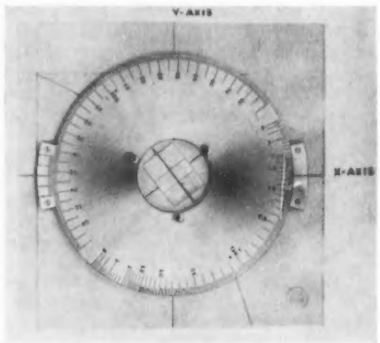
ILLUMINATED numerals visible through small windows indicate the time directly in hours and minutes, and the second hand is replaced by a rotating dial in a new clock, of the cyclometer type, operated by a small synchronous motor. Among expected applications will be the timing of long-distance telephone calls. Surgeons in operating rooms, where the matter of seconds is vitally important, will find it useful. In railroad stations this clock would give the time as it is listed in railroad time-tables.

Richards-Roope Tangent Meter

Bausch & Lomb Optical Co.

FOR those who work with graphs, this instrument has many applications. It is a simple device for the direct measurement of the tangent to a curve at any point. The derivative curve may then be rapidly and easily obtained by plotting the tangents. Since the measurements may be made as near each other as is desired, maximum, minima and points of inflection may be found without reference to the rest of the curve, as would be required by numerical methods such as finite differences.

The instrument consists of a rectangular transparent Zylonite base upon which rotates a circular metal disk with center cut out to hold a glass disk on which is mounted a right angle, isosceles prism. The lateral edge of the prism is directly over the center, which is indicated by two crossed lines. The metal disc is graduated with a protractor degree scale and with a tangent scale. By means of a vernier and of a tangent index, tangents to unity (45°) may be read directly to 2 parts in 100 and may readily be estimated to 1 part in 100.



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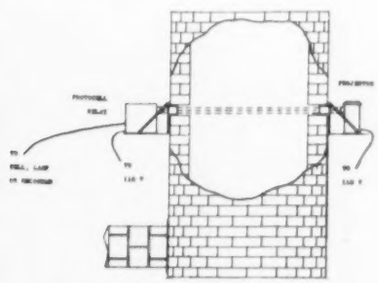
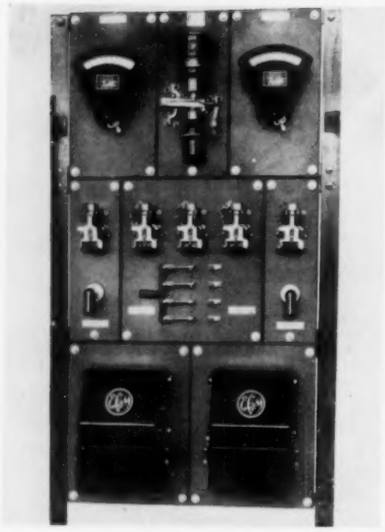
Smoke Density Meter

American Photoelectric Corp.

OPERATING from a.c. or d.c. supply mains; for interior installation (as illustrated) or in weatherproof housings; this equipment consists of (1) a special projector, its mounting bracket, etc., and (2) a photo-



cell relay complete with photocell and amplifier tubes, likewise mounted on a bracket. Holes 3" in diam. must be made in the stack or flue. The bracket face plates completely cover these holes. The amplifier output is used to operate the required indicator, recorder or signal.



Full Automatic Pump Control

Electric Controller & Mfg. Co.

THIS new control panel is designed for use with 2 motor-driven pumps which discharge into the same tank or system. It automatically starts and stops both pumps, or either unit alone, if one is sufficient to meet the demand, so as to maintain the tank level (or pressure in the system) within extremely close limits.

Since, with one pump operating, the friction head of the system increases when the second pump starts up, provision must be made to compensate for this in order that the pumps shall operate until the level has reached the high limit. Likewise, with both pumps running, if an abnormal condition trips the overload relay on one unit causing it to stop, protection must be provided to prevent overflowing the tank. This new panel automatically takes care of either condition by shifting the control to the proper gage so that both pumps will operate as long as necessary to fill the tank, yet with only one pump operating, the tank will not overflow. The panel is equipped with selector switches having 3 positions (Manual; Off and Automatic) to permit individual control of each pump unit. In addition, a transfer switch permits changing the sequence of operation in order to equalize the wear. The automatic starters for the two motors are EC&M oil-immersed which provide across-the-line starting and for this particular case are designed for 7½ h.p., 440 volt, 3 phase motors. Similar controllers for larger motors to provide either full or reduced voltage starting are available.

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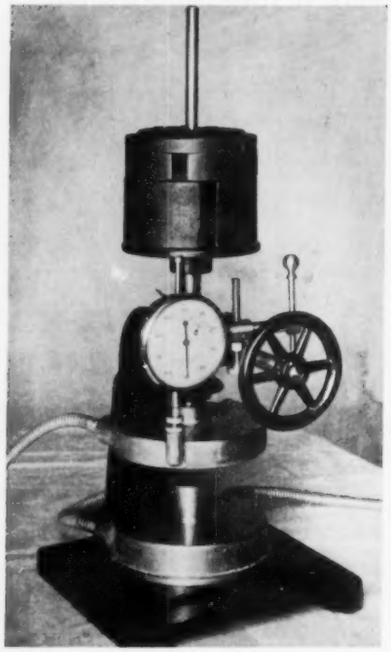
Plastometer

Henry Scott Co.

DEVELOPED as a practical tool for use in the mill room for control purposes, this new instrument should also prove of value in the technical laboratory as it is so constructed as to offer many experimental possibilities.

New design features solve the problem of control through plasticity. No temperature controlled oven or other accessories are needed (except a timing device) and no definite size of specimen is required for the test.



The platens are hollow cavities and so arranged that they may be heated or cooled by circulation of steam, hot water, brine, etc. The lower plate is arranged with a plug 1" high, 1" in area. This plug is hollow, the same as the rest of the lower plate and so arranged that all the circulation must pass through it. The upper plate, a flat surface, is attached to a spindle slideably mounted in a heavy cast iron frame, and may be raised or lowered by means of a handwheel. A weight holder is on top of this spindle on which loose weights of the conventional scale type are placed.

Two stops are arranged, one to hold the plates at the maximum point of separation, the second to hold them separated at any predetermined distance. A gage reads zero when the plates are together, and gives micrometer measurements of the entire movement of the spindle.

The machine illustrated is of the low load type with a minimum pressure of 5 lbs. Machines of lower minimum are specially made to suit special conditions.

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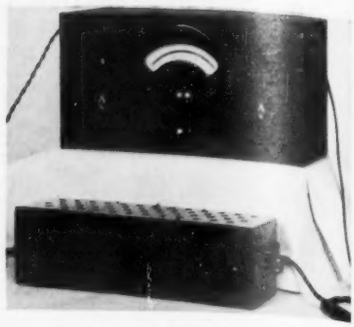
"1-2-3-5" System Weights

Pfaltz & Bauer, Inc.

SAVINGS in the number of weights used for weighings (with fewer errors), and in handling time, are said to be effected by the use of the new system Sartorius weights. From 1 mg. to the highest gram weight in any assortment, the series runs 1, 2, 3, 5, 10, 20, 30, 50, etc. Since there are no 2 weights of the same denomination no time is lost in the identification of weights and a single calibration correction is applied to any particular mass rather than the tedious process of applying a correction for each weight. The assortments are adjusted to Bureau of Standards requirements or to twice the Bureau's Class S tolerance. Gold-, platinum-, or chromium-plated weights are furnished.



Magnetic Impurities Detector

General Electric Co.

MAGNETIC impurities in asbestos, mica, glass, sands, and other similar materials are detected and their extent measured by means of a new magnetic device, first developed for use in the company's shops for determining the amount of magnetic oxide of iron present in asbestos, but now expected to have wider application in industry. The new device operates on 110-volt, 60 cycle circuits; and can be used by workmen unskilled in electrical measurements.

Both free iron and black ferric oxide are conducting and magnetic, and if present in asbestos are detrimental to its insulating qualities. The more common oxides of iron are, on the other hand, non-magnetic and non-conducting. By chemical analysis, all of the iron and its oxides are determinable only as total iron present—no differentiation may be made between the injurious and the non-injurious types. The new analyzer, on the other hand, reports only the magnetic content. It consists of a differential permeameter and an indicating device. In the case of asbestos, the magnetic effect of the iron impurities is proportional to the quantity of impurities present. The permeameter consists essentially of a coil for producing a high magnetic field for magnetizing the specimen, and 2 equal secondary coils for measuring the magnetic effect. These latter coils are placed in the magnetizing coil and connected to the indicator with their induced voltage in opposition. The specimen is placed in one of the secondary coils, thus disturbing their electrical equality. The effect on the indicator is proportional to the quantity of magnetic impurities present. The indicator has 2 scales calibrated in terms of the percentage of impurities in a 10-g. specimen. The range of the first is up to 1%, and of the second up to 5%. Changing from one scale to the other is accomplished by means of a switch.

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Turbine Water Meters

Cie. p. Fabrication des Compteurs & Matériel d'Usines à Gaz

A NEW line of water meters has been brought out by the above-named company. The principal features are extremely low weight and price, and simplicity of construction. Correct registration at low rates of flow appears to have been realized with unusual success; some small models being furnished as combination meters and faucets. Dial registers (submerged) or cyclometer registers (dry) are optional.

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With the co-operation of the National Physical Laboratory

Volume X MARCH, 1933 Number 3

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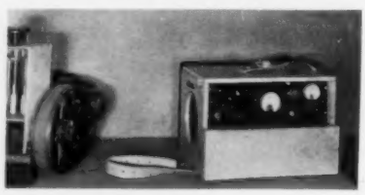

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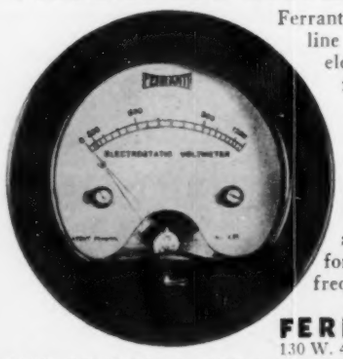

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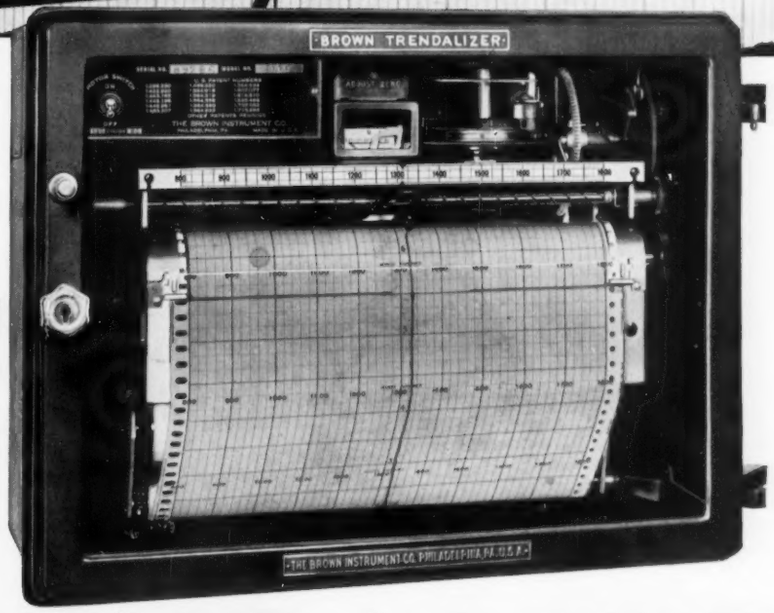

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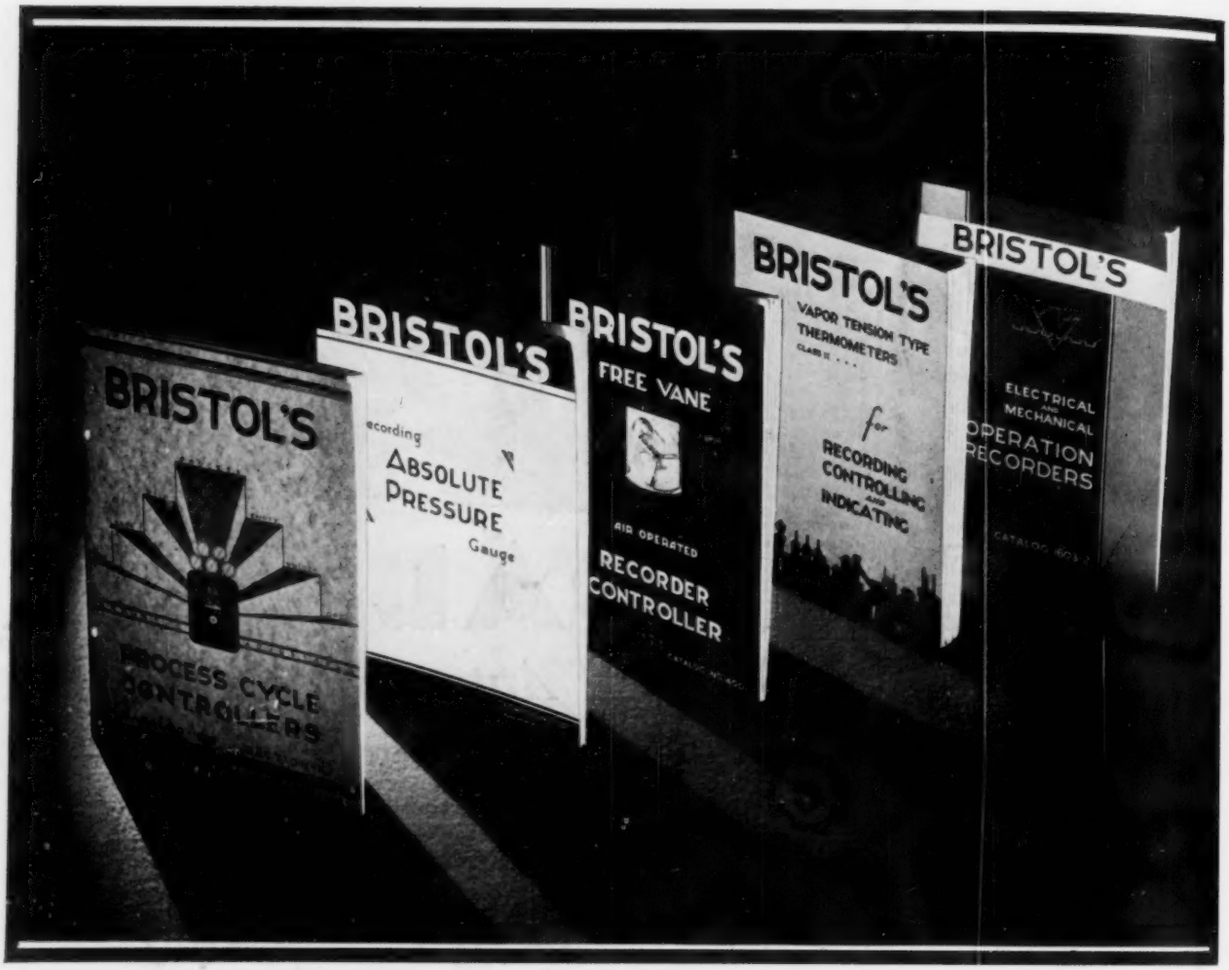

THERE HAVE BEEN many new developments in the instrument field during the past year or two. Much of this creative work has been done by Bristol engineers in the Bristol Laboratories. You will be surprised at the extent to which refinement in design and new ideas have made obsolete some of the splendid instruments of a few years ago.

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